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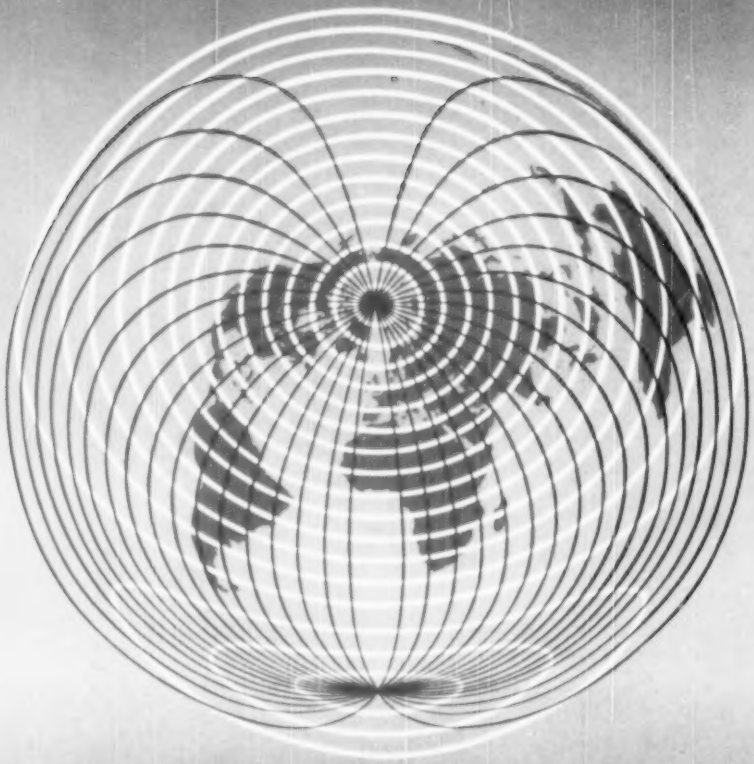

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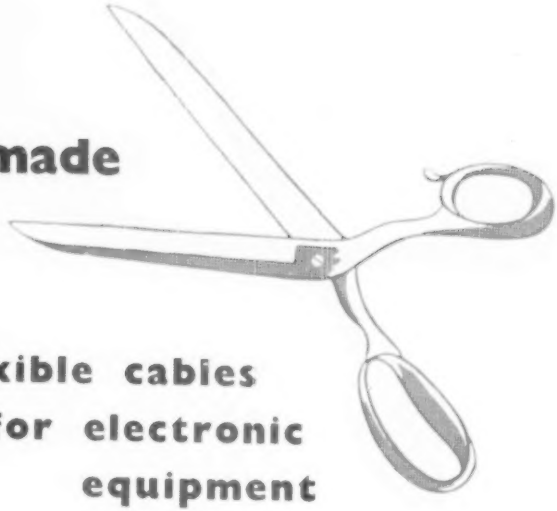

flexible cables for electronic equipment

If you need special multi-unit low-loss cables for electronic equipment—let us design and manufacture them to your requirements. They may include coaxial, twin, quad and small power or control cores in any combination.

BICC can offer you specialised production facilities for this work, as well as the services of skilled engineers who have tailor-made low-loss cables for all current requirements.

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Polythene-insulated P.V.C. sheathed multi-core cable with microphone and control cores for film studio use.

Multicore polythene-insulated and sheathed television camera cable. Overall diameter 0.5 inches.

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Co-axial socket for attenuated output. Force socket located totally within H.F. compartment.

MAINS TRANSFORMER — 2
Marked tagboard for inputs of 100–130V. and 200–260V., A.C. 50/60 c/s.

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Employs close tolerance, high stability midget carbon resistors, low reactance rotary potentiometer modified for H.F. operation with carefully designed screening.

Other features include

ILLUMINATED SPOT RANGE SELECTOR
Gives rapid identification of operational band with intensified lighting round precise frequency. Fine hair line gives close discrimination, particularly on high frequencies.

STOPS
Separate stops prevent turning of dial with respect to condenser.

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This is screened from main electrical assembly

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provide additional rigidity for rotary controls

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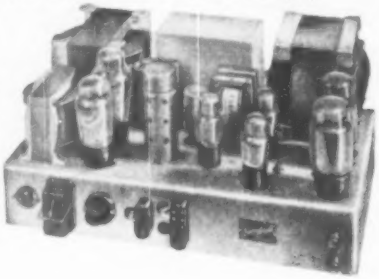

Williamson amplifier to specification. Illustrated is the dual power supply model with Partridge transformers, large paper condensers and B.V.A. valves.
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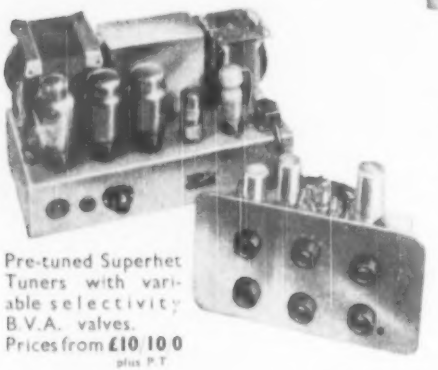
Other models from **£19 19 -.**



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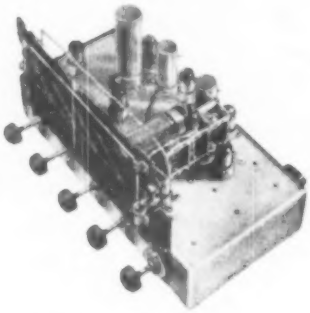

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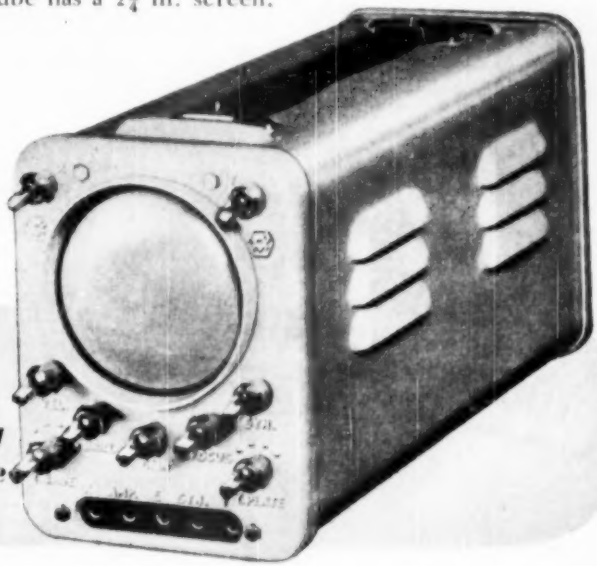

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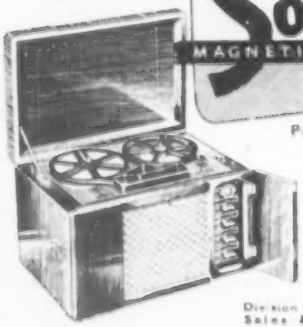

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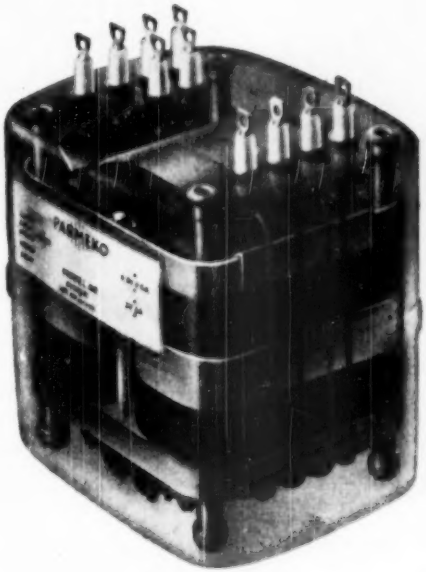

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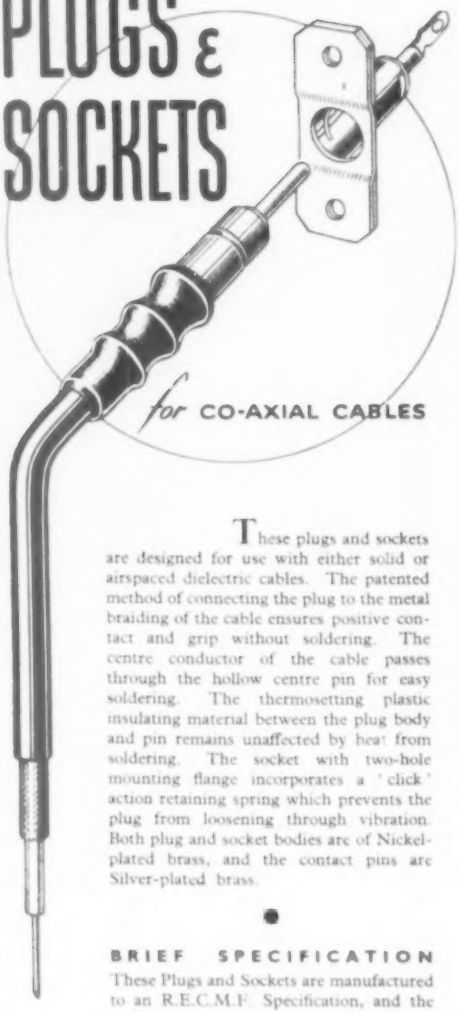

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Contact Resistance (Pin Contacts)	10 milliohms max.
Leakage Resistance	10 Megohms min.
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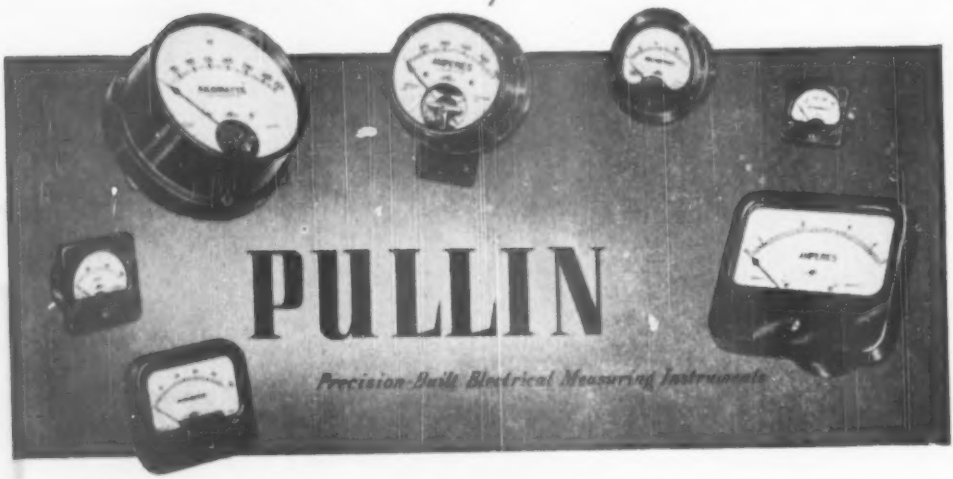

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The fault does not lie with the musician, nor with the measurements. Rather does it lie in the interpretation of those measurements. The output from a gramophone pick-up, for example, cannot wholly be represented by simple combinations of sine waves, neither can it be assumed to represent a near approach to the original sound.

Our Huntingdon laboratories have specialised in sound waves and methods of analysis, from very low frequencies in measuring anti-vibration devices up to ultrasonic equipment for medical research. They have produced the Corner Ribbon loudspeaker, amplifiers and other equipment used by the leading Broadcasting and Recording Companies both here and abroad. Even so, we cannot claim a perfect method of measuring the accuracy of a reproduced complex sound. The limitations imposed by a monaural system even precludes us from laying down an ideal specification.

On this page we mention five points which we know to be of the utmost importance in quality reproduction—points which are usually overlooked or to which insufficient attention is paid.

If you are a technical enthusiast you will find the Q.U.A.D. specification of the utmost interest and second to none. If you are a musician, you will find that the sound you hear bears a closer resemblance to the original sound than any amplifier yet offered to the public.

...more about the Q.U.A.D.

It is the only 'quality' amplifier which is not embarrassed by the presence of sum and difference tones falling outside the normal feedback range (strong beats in choral works, etc.).

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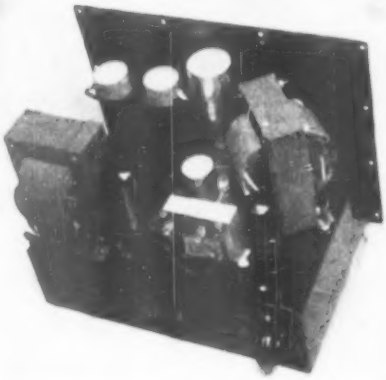

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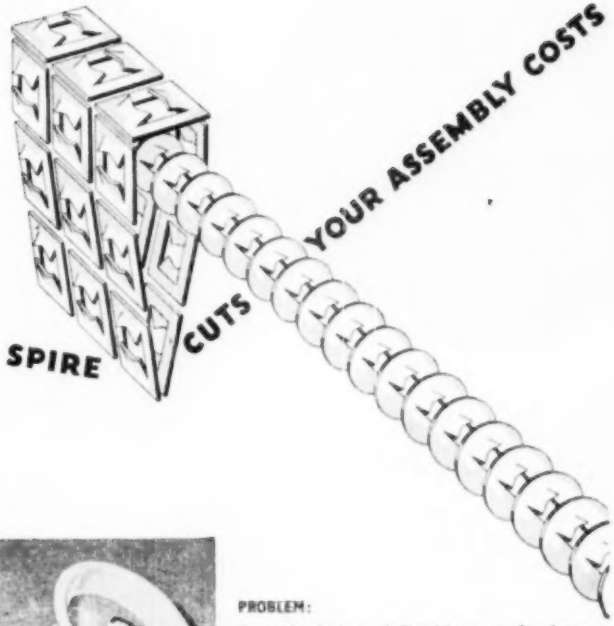

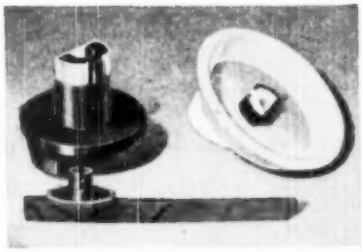

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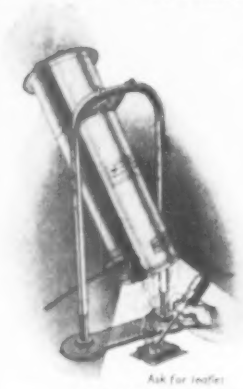

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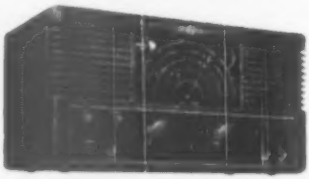

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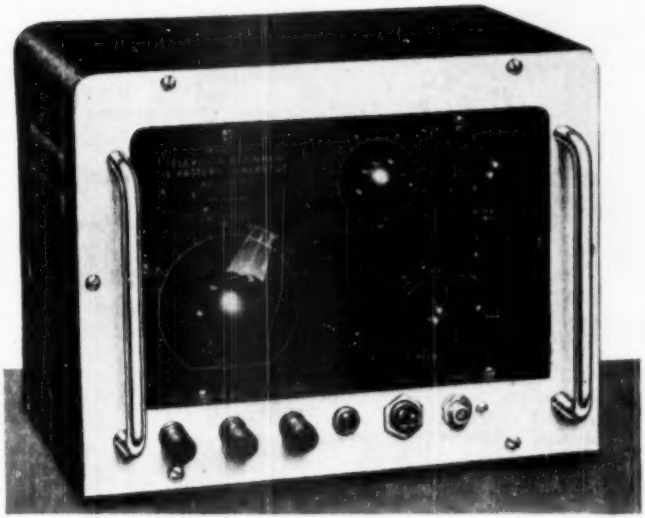

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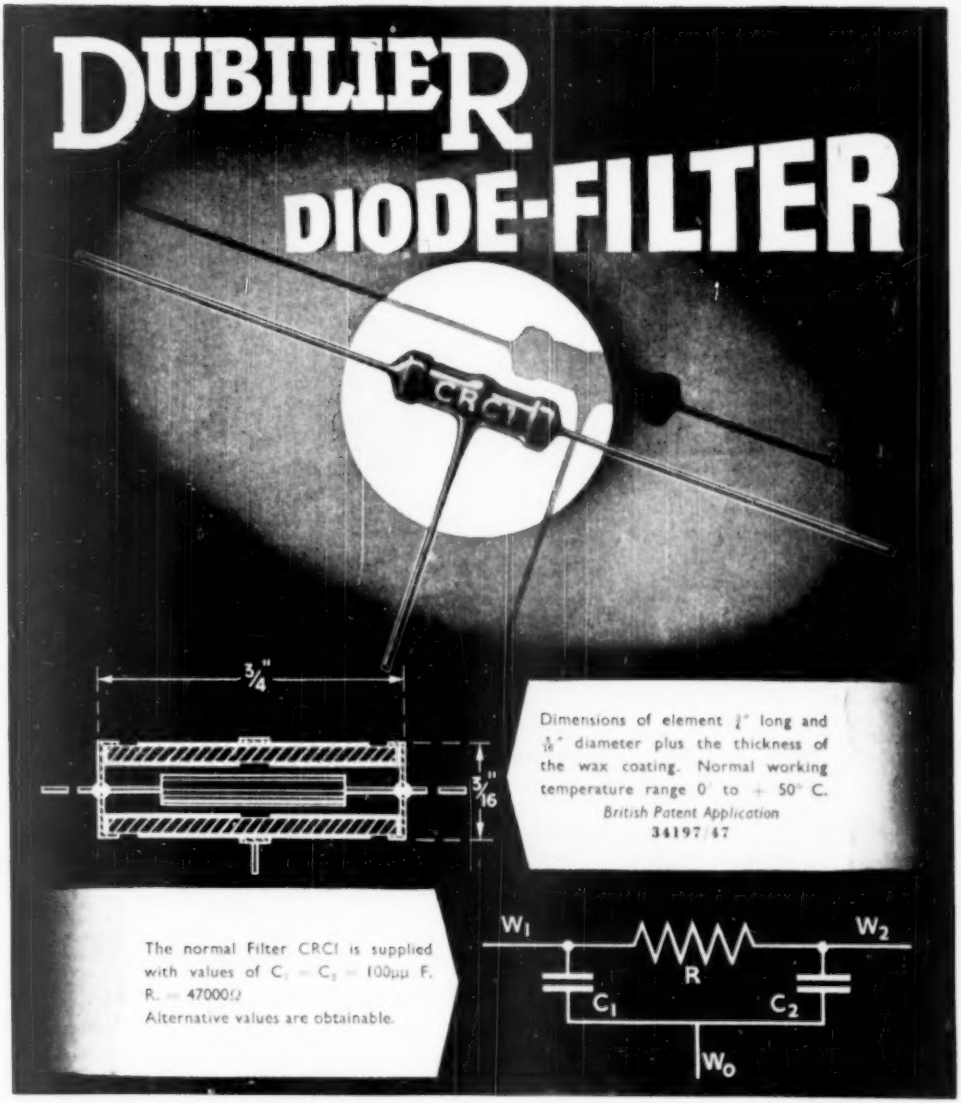

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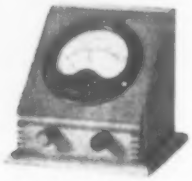

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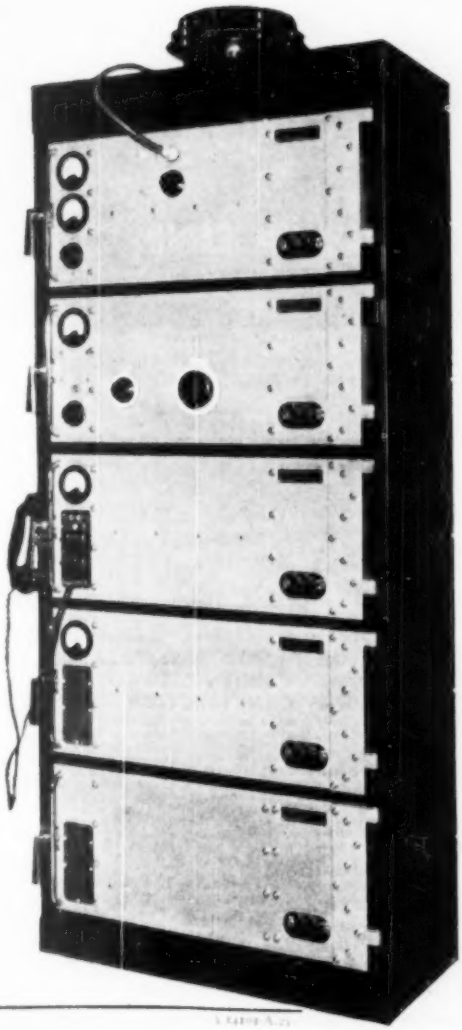

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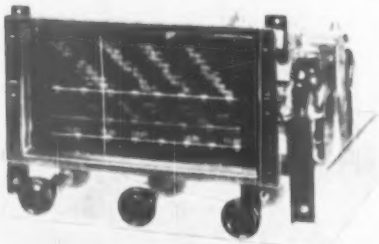

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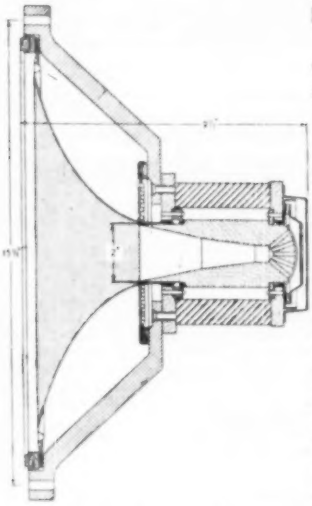

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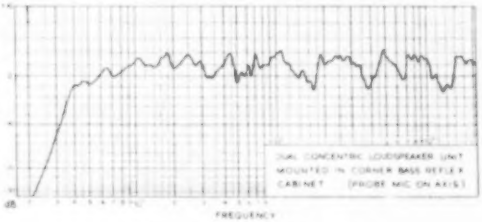

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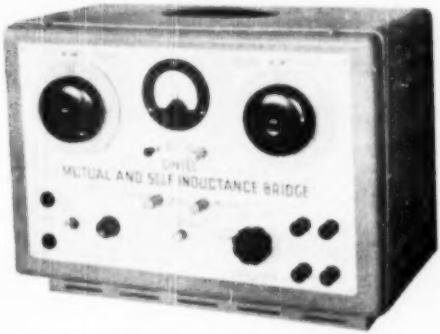

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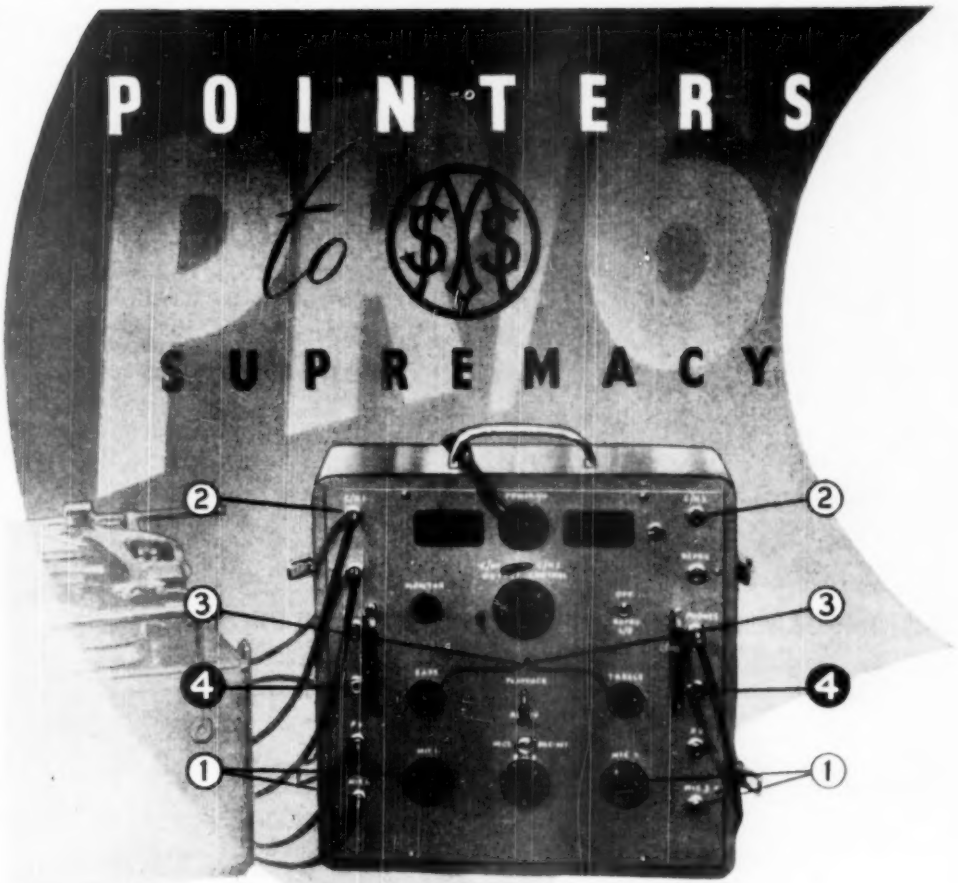

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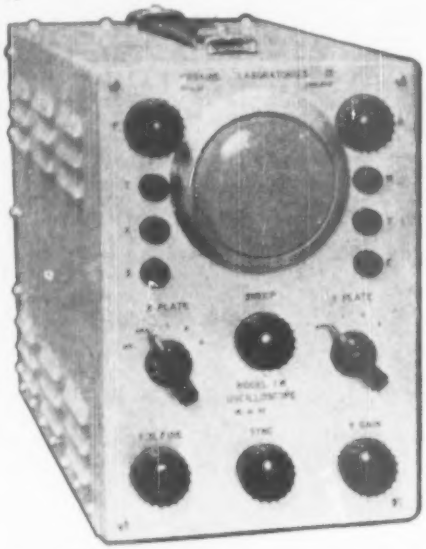

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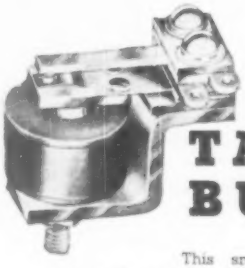

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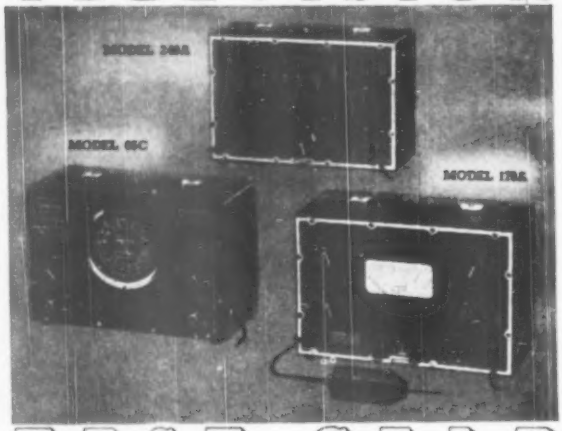

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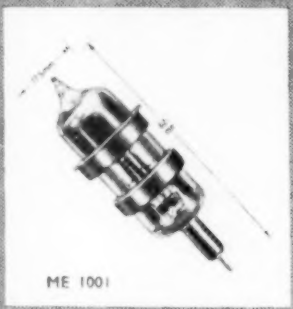

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	ME 1001	ME 1003
Heater Voltage (V)	6.3	6.3
Heater Current (A)	0.4	1.0
Max. Anode Voltage (V)	350	500
Max. Anode Dissipation (W)	10	25
Max. Anode Current (mA)	50	200
Max. Peak Anode Current (mA)	150	500
Power Output (W)	0.5 (at 3000 Mc/s) 3.5 (at 500 Mc/s)	6 (at 1500 Mc/s) 20 (at 420 Mc/s)
Mutual Conductance (mA/V)	6	12
Amplification Factor	30	30

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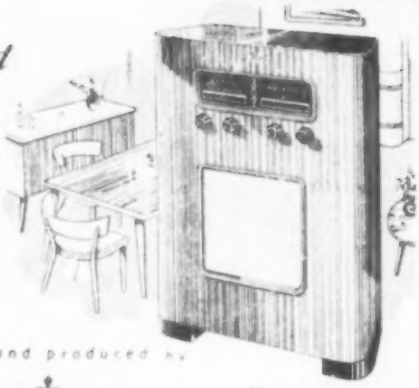

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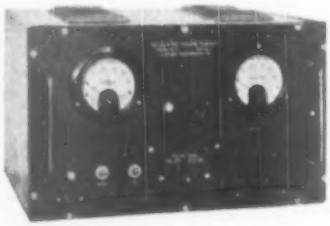

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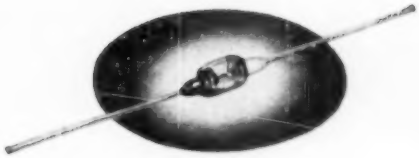

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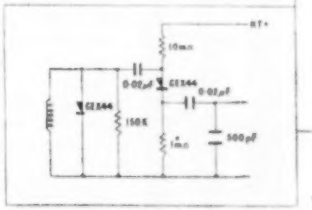

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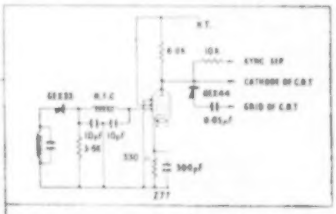

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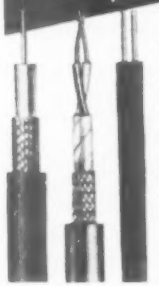

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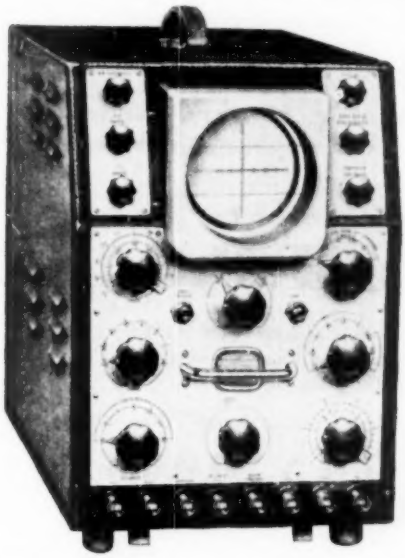

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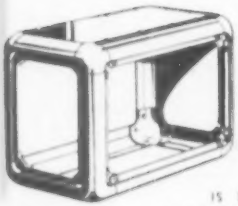

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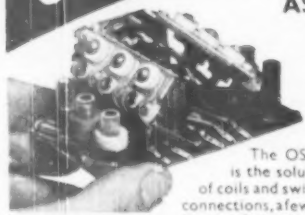

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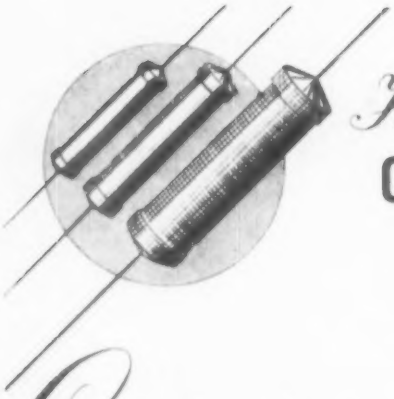

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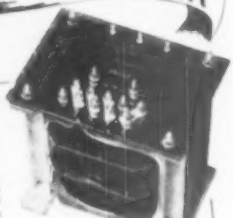

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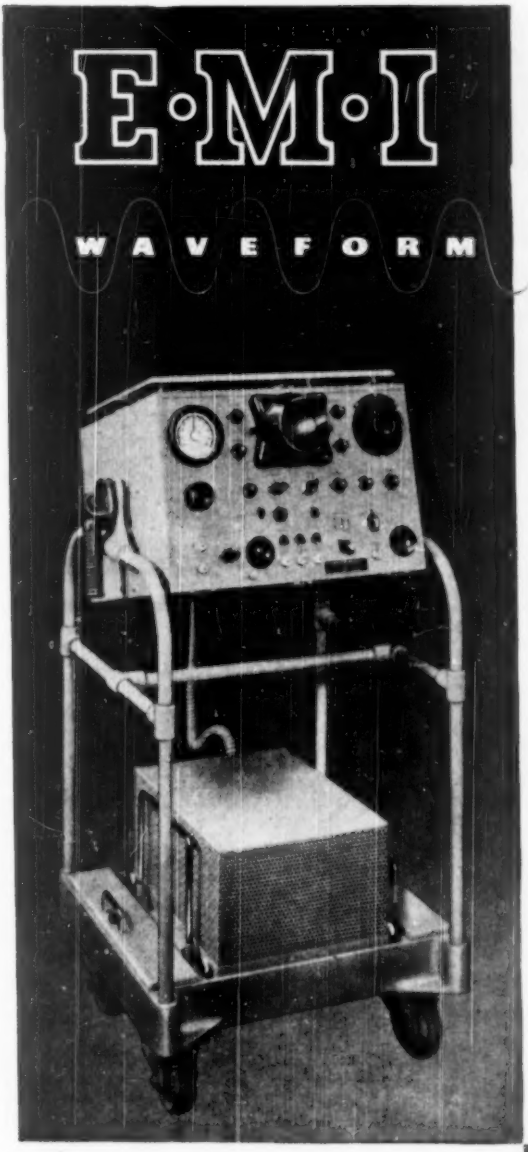

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An instrument designed to meet television and radar test and research requirements with comprehensive facilities for the intimate study and precise measurement of complex waveforms.

TYPE 3794 OFFERS:

- Direct measurement of A.C., D.C. or mixed voltages from 0.05 to 500.
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- A wideband vertical axis amplifier giving a time of rise of 0.08 μs. without overshoot on steep wave fronts.
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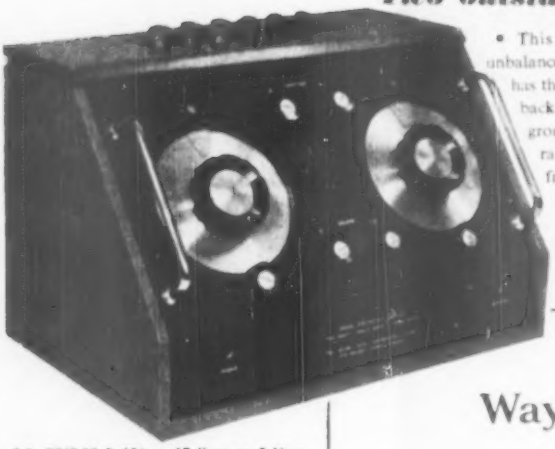

• This bridge not only measures balanced or unbalanced impedances with equal facility, but also has the merit of extremely low impedances looking back into the terminals and from the terminals to ground. It provides, at radio frequencies, the range, flexibility and stability of an audio-frequency impedance bridge and, having a neutral terminal available, it permits the measurement of three-terminal networks. A high degree of accuracy is maintained throughout the full frequency range.

R.F. BRIDGE B 601 — 15 Kc/s. to 5 Mc/s.

Capacity: 0·01 pf. to 20,000 pf. in five ranges. Resistance: 10 ohms to 10 megohms—6 ranges. Inductance values which will resonate the above capacities between 15 Kc/s and 5 Mc/s. Direct reading accuracy is constant to within 1% up to 3 Mc/s and may fall to 2% at 5 Mc/s.

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Impedance 14,000 ohms at 1,000 c.p.s. Sensitivity 8 Dbs below 1 microwatt per bar at 1,000 c.p.s. Weight 9 ozs.

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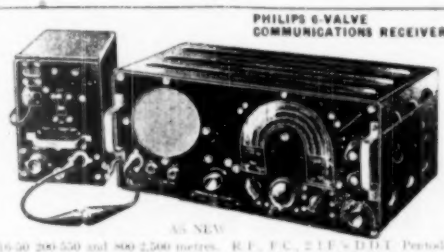
N.B.—There is a shortage of Utility Sets but we have been fortunate in selecting these with the above excellent 2-waveband receiver.

PRICE **90/-**

Carr. and pkg. 7/6

PHILIPS 6-VALVE COMMUNICATIONS RECEIVER



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16-50, 200-550 and 800-2,500 metres. R.F., F.C., 2 I.F.s D.D.T. Pentode Output. Spin-wheel tuning. In black metal case with built-in speaker. Complete with power pack, AC 200/250 v. Can also be supplied with 12 v. D.C. power pack if required. **£16.10.0**

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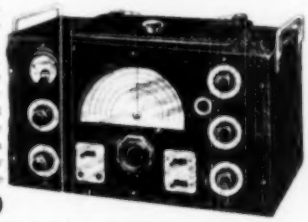
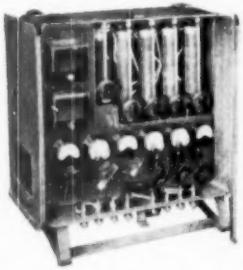
Great Reduction in Price



Range 31 Mc/s to 90 kc/s, 9 Plug-in coils, 7 valves and rectifier, variable selectivity, R.F.O. stand-by switch, A.V.C. switch, band-spread dial, valve check meter. In heavy black crackle finished steel cabinet with chrome fittings. Complete with 200/250 v. A.C. Power Supply Unit. Carriage and packing 17/6 extra. **£20**

VALVE TESTER by Precision Apparatus Co., N.Y., U.S.A. For all American type valves. 115 volts. **£10.10.0**

CHARGING BOARDS. Control Panels Only



24 v. 1,200 watts. Includes five 1½ in. moving coil ammeters (1, 0-40 a.; 4, 0-15 a.). One moving coil voltmeter 0-40 v. Five heavy duty sliding resistances, etc., complete in Metal case as shown with fold back doors. Size 18 × 17 × 8½in. Offered at less than half the component value. Price **£4.19.6** Carriage extra.

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TWIN SLIDING RESISTANCES. 120 ohm., 2 amp. **22/6**

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2 volt in black bakelite case, 15-20 amps. Size 6in. × 1¾in. × 1¾in. square. Weight 26 ozs.

Brand new. Carr. paid. **5/6**

Or in lots of 24 ... **30/-**

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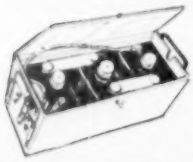

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N.B.—We cannot enter into correspondence regarding these cells.

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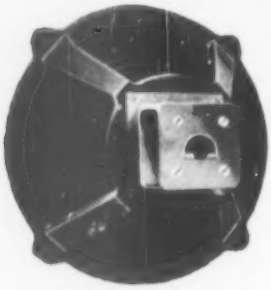

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Flux Density 13,500 lines/cm². 2" centre pole. Total Flux 180,000 lines. Speech Coil 6 or 15 ohms. Peak input 15 watts. Chassis diameter 14½ inches. Weight 17 lbs.

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Armature resonance	16 kc/s	9 kc/s
Output	70 mV	Equivalent to 150 mV on 78 r.p.m.
Tracking weight	15-20 grms	7 grms
Load	30 k Ω	30 k Ω
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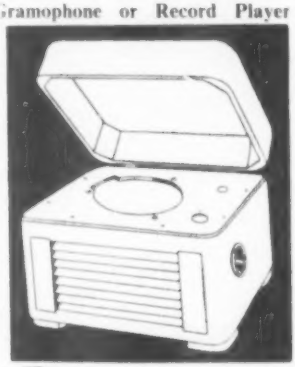

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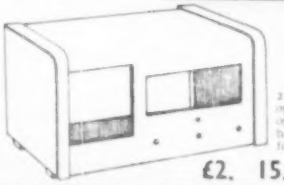

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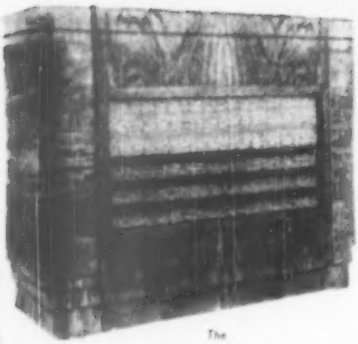

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Acoustically Designed Cabinets

by

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Unit construction. New Acoustic treatment. Easily unassembled for Export. These are but a few of the points in the design of this new cabinet work. Enquire now for details, which will be forwarded when ready.

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Permission has been granted to us to manufacture for sale this high quality cabinet, and it is manufactured to the design of the British Broadcasting Corporation, and protected by B.B.C. Patent Application No. 24528/49.

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Adaptor Unit S.C. "88" eliminates costly troublesome conversions

IT ADAPTS THE "LONDON"-DESIGNED TELEVISION RECEIVER FOR SUTTON COLDFIELD RECEPTION'—PERFECT SOUND AND VISION

Small and compact, the unit, embodying power-pack, and all the necessary "works," is simply fitted between aerial and set. Set itself is entirely untouched, and in its original state—thus retaining its full "design-efficiency." Of particular interest to "Fringe" viewers. Real saving of time, trouble and cost.

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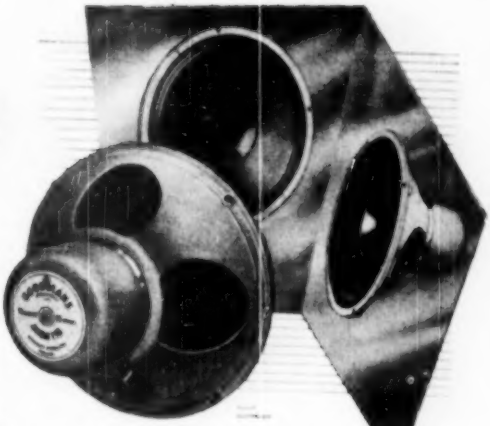
This 12" high fidelity unit has a twin-curvilinear diaphragm (Patent No. 451754). A carefully designed magnet assembly using anisotropic material provides a total flux of 158,000 maxwells on a 1½" pole. The back centring device is a dustproof bakelised linen disc with concentric corrugations.

The combination of these features gives this precision built instrument an outstandingly wide coverage from 40 to 15,000 c.p.s. free from base modulation effects.

An ideal high fidelity reproducer for the record enthusiast and the connoisseur of wide range musical reproduction, it gives exceptionally fine transient and frequency response.



Frequency Coverage	40-15,000 c.p.s.
Overall Diameter	12⅜"-31.3 cms.
Overall Depth	6⅞"-17.6 cms.
Fundamental Resonance	55 c.p.s.
Voice Coil Diameter	1¾"-4.4 cms.
Voice Coil Impedance	15 ohms at 400 c.p.s.
Maximum power Capacity	15 Watts Peak A.C.
Flux Density	14,000 gauss
Net Weight	12 lbs. 13 oz. 5510 grammes
Finish	Grey Rivelling Enamel

£8.8s. LIST

For use with this model we recommend Goodmans High Fidelity Heavy Duty Output Transformer Type H.4. Nett Weight 5 lbs.—2,265 grammes.

A Bass Reflex Cabinet measuring approximately 30" 23" 16" and a corner cabinet have been specially designed for this loudspeaker and working drawings are available

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And a Richard Allan Speaker to go with it, Sir!

If you have a Radio set you need a Richard Allan extension speaker.

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Bafflette	£4 4 0
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6-valve p.p. Amplifier. 8-in. H. Duty Speaker. Powerful 10-W re-play. 3 speeds, twin tracks, ½ hr continuous play, music at radio quality with 1 hr speech. Will record from radio disc or mic, with fader mixers on two inputs. Uses crystal or m.c. Also makes powerful P.A. Sound from mic, gram or tape recordings.

This powerful, portable record-playback machine will faithfully record on plastic tape from a mere whisper to full orchestra. Re-play at astounding quality and volume equal to largest radiogram. New circuitry gives wide frequency range of upper and lower for true reproduction unmistakable from the original.

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Model 51 in handsome leathercloth case to include microphone and four reels, dimensions 15 × 10 × 11 in. high, weight 32 lb. Price, complete with crystal microphone and tape, **£57 15s. 0d.**

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We are so convinced you will agree, that we shall be pleased to send either model on TEN DAYS FREE TRIAL on receipt of deposit.

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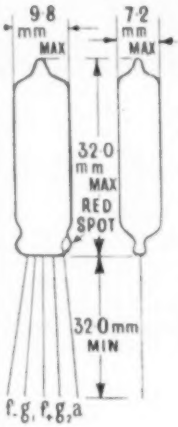
XFW20



The XFW20 is a subminiature voltage amplifier pentode with a filament current of only 12½ mA.

It is a robust, reliable valve having a high gain and very low microphony.

Its principal use is in the early stages of hearing aids, but it has applications in many small instruments.

TYPICAL OPERATION

Filament Voltage	**0.625v**
Filament Current	**12½mA**
H.T. Supply Voltage	**22½v**
Anode Load	**1 to 2 MΩ**
Screen Resistance	**3 MΩ**
Stage Gain	**32**

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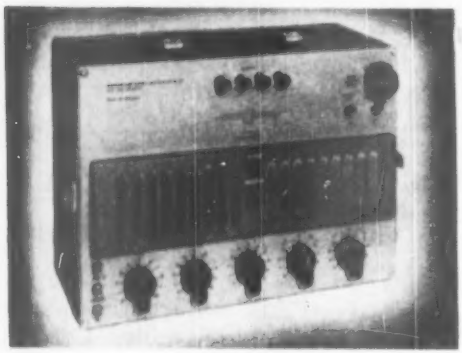

An attractive appearance and unique construction combined with first-rate performance give this instrument a hallmark of distinction. Peak power 40 watts, 30 watts undistorted. Designed for both A.C. Mains and 12-volt battery operation. Provision for independent electronic mixing of two microphones and one gramophone channel. Built-in vibrator. Special tone control circuit, with independent bass boost and cut, and treble boost and cut.
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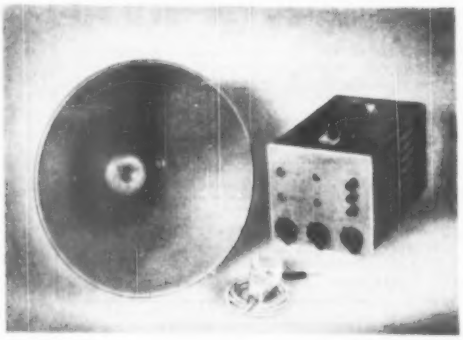

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A 30 watt amplifier for public address men. Inputs for moving coil or ribbon microphones and gramophone. Tone control. Illuminated panel and output signal level indicator. Outputs: 7.5, 15 ohms and 100 volt line. Operates from 200-250 volts A.C. mains, or 12-volt battery when used with battery adaptor unit type LT30. An ideal equipment for P.A. vans, general installations and outdoor requirements. Supplied in a handsome portable case.
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Wireless World

RADIO, TELEVISION AND ELECTRONICS

December 1950

40th YEAR OF PUBLICATION

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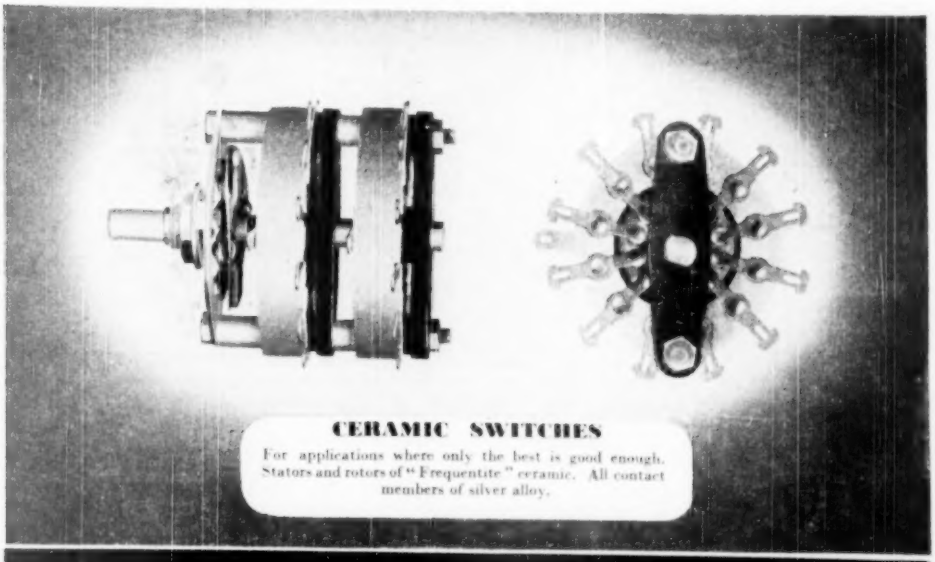

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Important trends in

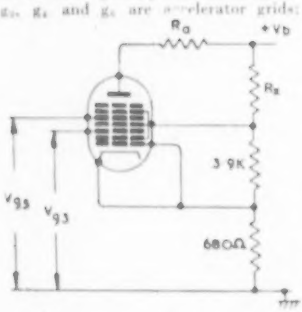
VALVE DESIGN

MULLARD NONODE F.M. DETECTOR TYPE EQ80

Although frequency modulation is not employed in the British television system, a valve suitable for use as an F.M. detector has been included in the Mullard World Series of television valves, because the F.M. technique has been adopted for the sound transmission in the television systems of some other countries.

The EQ80 is a nonode (nine electrode valve) which can be operated as a combined F.M. detector and limiter.

Of its seven grids, g_1 is a biasing grid; g_2, g_4 and g_6 are accelerator grids;



V_b (V)	R_g (KΩ)
250	34
200	26
170	21

g_3 and g_5 are signal grids; and g_7 is a suppressor grid connected internally to the cathode.

The operation of the EQ80 as an F.M. detector is based upon the following considerations:—

(a) If the potentials of g_1 and g_2 are fixed, the cathode current is substantially constant and its value is determined almost entirely by the potential of g_3.

(b) If g_3 is sufficiently negative to g_1 the whole of the cathode current will flow to g_2, but, if g_3 is even only slightly positive to g_1 most of the current will flow towards the remaining electrodes, i.e. in the direction of the anode.

(c) Because the total cathode current has been determined by the potential of g_2, an increase in the positive potential of g_3 will only slightly affect the value of the current towards the following electrodes.

(d) Similarly, if g_5 is sufficiently negative with respect to g_4, the whole of the current will flow to g_4 and the anode current will be zero; but if g_5 is even only slightly positive, most of the current will flow to the anode, and its value will be practically independent of the positive potential of g_5.

It will thus be seen that no anode current will flow unless both g_3 and g_5 are positive, and that the value of the anode current will, to a great extent, be independent of the positive potentials on these two grids.

If to g_3 and g_5 are applied signal voltages between which there is a varying difference in phase, and if, as can quite easily be arranged, the phase difference between these two voltages varies substantially linearly with the instantaneous frequency of the F.M. signal, anode current will flow only during that portion of each period when both g_3 and g_5 are positive, and the duration of that portion will depend upon the phase difference at the moment. This means that the mean anode current varies with the instantaneous value of the phase difference—in other words the valve operates as an F.M. detector and limiter.

RATINGS AND CHARACTERISTICS

Heater Suitable for series or parallel operation, A.C. or D.C.

V_h	6.3 V
I_h	0.2 A

Characteristics

Values refer to circuit shown

V_b	170 to 250 V
$V_{g2, g4, g6}$	20 V
V_{g1}	−4 V
$V_{in(g3)}$ r.m.s.	12 V
V_{g5}	−4 V
$V_{in(g5)}$ r.m.s.	12 V
Phase angle between signals in g_3 and g_5	90°
R_a	0.33 M
I_a	0.28 mA
$I_{g2+g4+g6}$	1.5 mA
I_{g3}	0.09 mA
I_{g5}	0.03 mA
r_a	5 MΩ

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MVM153

Wireless World

VOL. LVI. No. 12 DECEMBER 195

Half a Loaf

IN spite of constant pressure for several months, the authorities hold out no promise of restoring the Airmet transmissions of meteorological data. In November, the Postmaster General, answering in Parliament several questions on the subject, acknowledged the value of the service to various sections of the community but expressed regret that it had been found impracticable to make any broadcast frequency available for the restoration of the service. He went on to say the possibility of improving the weather information available to the public was being considered in conjunction with other departments and the B.B.C., and he understood that some amplification of the B.B.C. weather forecasts would be introduced shortly.

From this we gather there is little prospect of resumption of the original Airmet service, transmitted either by the Air Ministry or the Ministry of Civil Aviation, and we are confirmed in our belief that any improved service for which we may hope will eventually be broadcast by the B.B.C. The Corporation is, we believe, the proper authority for distributing a service that, after all, is of more or less direct benefit to the whole community, though only of incidental concern to any particular Ministry.

Unfortunately, however, the "amplified" B.B.C. weather service foreshadowed by the Postmaster General has turned out to be something that can barely be called even a compromise. All we can say in its favour is that the change in the method of forecasting does at least acknowledge the possibility of improving the old system. The total time given daily to the weather has not been increased, but the 6 p.m. bulletin has merely been improved insofar as the various stations deal with the weather in their own areas, and so can treat it in somewhat greater detail than if they were dealing with the country as a whole. That, of course, is a step, but only a very small one, in the right direction. The B.B.C. authorities must go much farther when they ultimately assume the responsibility—which we believe will inevitably be theirs—for distributing the improved service of weather bulletins of which this country, with its uncertain island climate, stands so much in need.

It is no business of *Wireless World* to go into the question of what constitutes an acceptable service. All we need say is that it should be much more detailed, localized and frequent than at present. Our concern is merely to press for a proper use to be made of radio in the one sphere where it is the only practicable medium for the distribution of information to the general public. We believe fresh weather charts are prepared at the Central Meteorological Office every three hours of the twenty-four, and it can be argued that broadcasts should be no less frequent. It must be galling for a forecaster to be unable to pass on up-to-date information for the reason that there may not be another broadcast for as long as 13 hours. Then there is the question of data (as opposed to forecasts) which, on the Airmet system, allowed the listener to follow the pattern of rain or sunshine across the country and, if not to do his own forecasting, at least to cross-check the official assessment of the situation as it affected him personally.

We doubt whether it was worth while disturbing the old-established B.B.C. routine for the trivial change that has been made. Something much more drastic, providing the detailed localized and frequent bulletins admitted to be necessary, must be done if radio broadcasting is to establish itself as the source *par excellence* of up-to-date weather information.

Fairly obviously, the ideal bulletin, or rather system of bulletins, would be planned by a meteorologist with a sympathetic understanding of the needs of the widest possible circle of listeners. Not only should the information most needed by the majority be given, but the timing and make-up of the various sections should be so arranged and standardized that the user of the service would be able to obtain what he wanted without wasting too much time in listening to those parts of the bulletin outside his individual concern.

Aerial Feeder Connections

Balance-to-Unbalance Transformer

By W. T. COCKING, M.I.E.E.

THE connection between the aerial and the receiver does not always receive the attention which it deserves, even in these days when so much is known about cables and their terminations. The need for matching is generally realized but the desirability of including balance-to-unbalance transformers is all too often unrecognized.

The ordinary receiver requires an unbalanced input; that is, of its two input terminals one is earthy and the other is live. The dipole aerial, however, is balanced to earth. Neither of its two terminals is earthy, but they undergo equal and opposite variations of potential with respect to earth.

Feeder cables are of two kinds, balanced and unbalanced. The first is the twin-wire feeder, which may or may not have an outer screening sheath. It is intended to operate in the balanced condition so that at any point along its length the potentials of its two wires are equal and opposite with respect to earth. Such a feeder is clearly suited for direct connection to a dipole aerial, both being balanced structures, but is not suitable for connecting directly to the receiver.

The second type of feeder, the unbalanced, is the coaxial cable. Equally clearly this is suitable for connecting to the receiver but does not fit into a direct connection to the aerial.

In practice, both kinds of feeder are commonly used in direct connection to both aerial and receiver and these improper operating conditions do not have any very obvious effect on the performance. The loss of signal is usually negligible, and although the polar diagram of the aerial may be affected somewhat the alteration is not at all evident.

Twin-wire Feeder

One characteristic of the system, however, is greatly affected. The feeder becomes liable to pick-up signals and so acts in some measure as an aerial instead of merely conveying the signals picked up by the aerial to the receiver. In many domestic installations this does little harm. However, if the feeder passes through a region of local interference it picks it up and passes it to the receiver, whereas it should be immune to it.

There is no doubt at all that in buildings containing electrical machinery a serious amount of interference can be picked up by the feeder. It is probable, too, that in the domestic installation more ignition interference may be picked up by the feeder than by the aerial in certain cases. It may well be that this will occur only in exceptional cases, but it is a point to watch.

A twin-wire feeder connected between the aerial and the first circuit of the receiver is shown in Fig. 1(a). Even if the earth connection to one side of the feeder is omitted, this feeder wire will be effectively earthed by capacitive coupling between the windings of the input transformer. The feeder is operated in a balanced condition at the aerial and in an unbalanced at the receiver and there is a gradual transition from the one to the other along the feeder. Now any voltages induced in the feeder, say at point A, by a local interference field, are equal in each wire and act in the same direction in both. Interference currents thus flow in the same direction in both wires.

At the receiving end the current in the earth wire flows to earth without harm but the current in the live wire flows through the coupling coil and so induces an interference voltage into the tuned circuit. However, if the feeder is terminated by a balanced circuit, such as a push-pull transformer, this can be avoided. This is shown at (b). The equal currents in the two wires flow through the two halves of the coupling coil and oppose each other in the winding. There is then no interference voltage induced into the tuned circuit.

In practice, the capacitance between the windings has a serious effect and the precise arrangement of Fig. 1(b) does not provide adequate immunity from interference. The effects of the capacitance can be overcome, however, by interposing a screen between the windings, as indicated in Fig. 1(c). If the secondary is the tuned grid coil of the first valve, the use of a screen may not be permissible, however. The screen greatly increases the capacitance of the circuit and so necessitates a lower inductance and a smaller shunt damping resistance if the bandwidth is

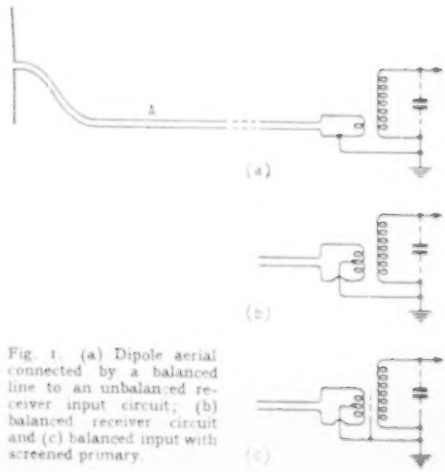


Fig. 1. (a) Dipole aerial connected by a balanced line to an unbalanced receiver input circuit; (b) balanced receiver circuit and (c) balanced input with screened primary.

to be maintained. In its turn this means a reduction of the voltage step-up between the feeder and the grid of the valve.

With a coaxial feeder the difficulty arises at the aerial end. Referring to Fig. 2, an interference e.m.f. induced in the outer of the cable sets up a current in it which flows round the complete circuit cable outer, lower half of dipole, capacitance to earth. The field here naturally energizes the upper half of the dipole also and a current is passed through the inner of the cable to the receiver. In effect, there is one closed circuit from earth through the cable outer, the lower dipole element and its capacitance to earth and there is a second closed circuit from earth through the receiver coupling coil, the cable inner, the upper dipole element and its capacitance to earth.

The capacitance to earth of the two halves of the dipole is largely common to both circuits and couples the two so that interference picked up in one circuit is transferred to the other.

Transformer Coupling

This effect can be avoided by including a push-pull transformer at the aerial end of the cable, as shown in Fig. 2(b). An interference current in the cable outer is now passed to the centre tap on the transformer primary and ideally divides equally through the two halves of the winding and passes to the two halves of the aerial. The currents are in opposition in the transformer and nothing is induced into the secondary which is connected to the inner of the cable.

Exact equality of currents may not be achieved because the capacitances to earth of the two halves of the aerial may not be equal. An electrostatic screen between windings is also often advisable, just as in the case of a receiver input transformer.

This form of transformer is very effective in reducing the pick-up of interference by a coaxial cable and in cases of bad interference can improve the signal/interference ratio by 20 db or more. It is not a method commonly adopted, however, largely because of the practical difficulty of weather-proofing the transformer. More often an equivalent result is achieved with resonant sleeves.

The use of such sleeves, or of resonant lengths of line, offers severe difficulties to the experimenter because it is not easy to determine their proper dimensions. They require adjustment *in situ* on the aerial. In addition, proper weather-proofing is not easy. The transformer of Fig. 2(b) is much more suitable for the amateur since it requires no adjustment, but the problem of weather-proofing is a difficult one for him to solve.

Although the actual coupling difficulties are much the same with any type of feeder the twin wire has the great advantage that the coupling transformer can be in the receiver and need not be up with the aerial exposed to the weather. Because of this, any adjustments to it can be carried out much more easily. It does seem, therefore, that the twin-wire feeder is more suited to amateur use than coaxial. It is also becoming more widely used in commercial television receivers, partly because it is cheaper and partly because there are no weather-proofing difficulties of the balance-to-unbalance transformer or "balun."

The precise arrangement of Fig. 1(c) is not often used at television frequencies, largely because the screen between the windings makes the capacitance

Fig. 2. (a) Dipole aerial connected by an unbalanced feeder to a receiver, and (b) a balance-to-unbalance transformer at the aerial.

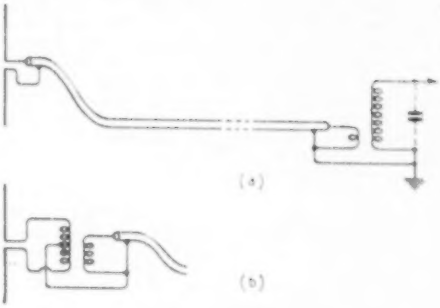


Fig. 3. In order to avoid a high-capacitance circuit at the receiver input a separate balun can be used.

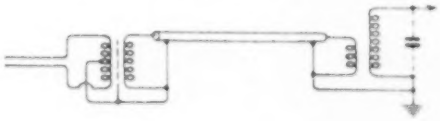
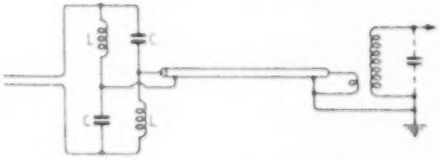


Fig. 4. The LC network shown gives a balun action without being a transformer.



on the tuned circuit so large that the voltage step-up in the transformer is greatly reduced. Instead a separate coupling transformer is often used. This arrangement is shown in Fig. 3 and the transformer is of 1 : 1 ratio with a centre-tapped winding and a screen between the windings. Because of the low impedance of the circuit—72Ω on each side—the capacitance is relatively unimportant.

If the transformer is physically close to the input circuit of the set the two can be directly connected, but if it is more than a few inches away a length of coaxial cable should be used to join them, as shown in Fig. 3.

This form of balun is not hard to construct and would be very easy were it not for the screen. Very tight coupling between the windings is necessary and the screen makes it difficult to get this. It is, however, possible to approach the screened condition very closely, without actually using a screen, by a particular form of construction. The secondary is wound with a strip of copper foil interleaved with paper for insulation. About 12 turns of ⅜-in strip, interleaved with a ⅛-in strip of paper, on a ½-in diameter former is about right. The inside end of the winding is the "hot" end and the outside end is

earthed. The centre-tapped primary of about 12 turns is wound as a single layer of wire outside the earthy turn, so that capacitive coupling exists only to one turn of the secondary.

It is possible to obtain the balun effect without an actual transformer, however, and an interesting circuit which is used in the latest Pye receivers is shown in Fig. 4. It has been previously described,[1] but is not as well known as it should be. The balance-to-unbalance is obtained from the network comprising the two equal inductances L and the two equal capacitances C.

The network has the configuration of a bridge and exact analysis can be quite complex. Fortunately, much of this complexity can be avoided if a little ingenuity is employed in devising equivalent circuits. The well known star-delta theorem, in particular, is a great help.

We want to know three things about the circuit :—

(a) Its input and output impedances.

(b) The ratio of the input to the output voltages (or currents or powers).

(c) Its balance.

Impedance

Let the impedance of the circuit connected to the input be Z_B and that connected to the output be Z_C. The circuit can then be drawn as in Fig. 5(a). The first thing to be noticed is that it is reversible. If we find the input impedance in terms of L, C and Z_C the output impedance is given by the same expression if we substitute Z_B for Z_C in it. We can see also that if Z_B and Z_C are equal the input and output impedances will also be equal.

To find the impedance we redraw the circuit as in Fig. 5(b) where Z_C is split into two impedances in parallel. The network comprises the series connection of two triangles of impedances (deltas), but twisted at their connection. If we apply the star-delta theorem to each we get the arrangement of Fig. 5(c), the corresponding points of connection in (b) and (c) being similarly numbered.

We can see at a glance that the input impedance is

$$Z_{IS} = 2Z_3 + (Z_1 + Z_2)/2$$

and inserting the L, C and Z_C values by means of the star-delta theorem (see Appendix) we get

$$Z_{IS} = Z_C \frac{2LCZ_C - j\omega L + 1/j\omega C}{2Z_C + j\omega L - 1/j\omega C}$$

It can at once been seen that if $LC = Z_C^2$ all terms in the fraction cancel and $Z_{IS} = Z_C$ at all frequencies. Similarly, the output impedance $Z_{IP} = Z_B$.

If LC does not equal Z_C^2, then at the resonance frequency of LC, and only at this frequency, $Z_{IS} = LCZ_C$. The circuit then acts as an impedance transformer of ratio $Z_{IS} : Z_B :: LCZ_C^2 : 1$. This action is not usually necessary and in what follows it will be taken that $LCZ_C^2 = 1$, so that $Z_C = Z_B = Z_{IS} = Z_0$. The terminal impedances must, of course, be pure resistances in this case, but this is the assumption usually made with circuits of this nature.

Transfer Ratio

It is possible to determine the ratio of output to input power from the circuit equations, but it is unnecessary to do so in this case. In the matched condition $Z_B = Z_{IS}$ and $Z_0 = Z_C$. The whole of the power delivered by the input feeder of impedance Z_B is, therefore, absorbed by the network without reflection. The whole of the output power of the network is absorbed in the output feeder of impedance Z_C equal to Z_B and again there is no reflection. The network itself comprises pure reactances L and C and so can itself dissipate no power. Hence, the input and output powers must be equal.

With $Z_C = Z_B = Z_{IS} = Z_0$, therefore, the output voltage, current and power are equal to the input voltage, current and power at all frequencies and the network introduces no loss.

In practice, of course, there will be some loss associated with L and C but this can be kept small by using high Q components.

Balance

Under one condition the balance is very easy to determine. This is when the unbalanced signal in the feeder is such that the two input terminals of the LC network are always at the same potential to earth. This means that in Fig. 5(a) the two ends of Z_B are at the same potential. They can, therefore, be joined together without affecting anything. One LC circuit then becomes a parallel-resonant circuit in shunt across the input and the other becomes a parallel-resonant circuit in series with Z_C. The equivalent circuit has the form shown in Fig. 6.

Since we are ignoring resistance losses in L and C this parallel-resonant circuit is of infinite impedance at resonance and at this frequency offers an infinite barrier to unbalanced signals at the input. At any frequency the ratio of output to input voltages is

$$\frac{e_0}{e_i} = \frac{1}{1 + jx(1 - x^2)} = \frac{1}{\sqrt{[1 + x^2/(1 - x^2)^2]}}$$

where $x = \omega\sqrt{LC}$.

If f_0 is the resonance frequency and Δf is a small change of frequency from this value ($\Delta f \ll f_0$) then approximately

[1] "Aerials for Metre and Decimetre Wavelengths," by R. A. Smith, p. 103, Cambridge University Press.

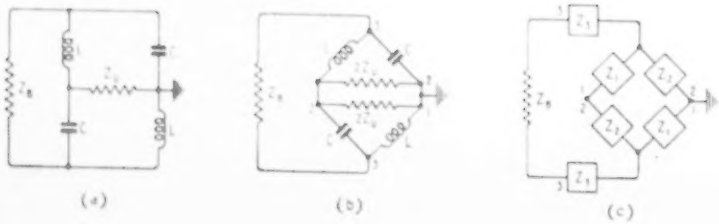


Fig. 5. Circuit of balun with its terminating impedances (a) an equivalent (b) and a further equivalent (c) obtained by the star-delta theorem.

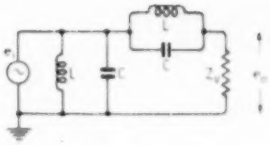


Fig. 6. Equivalent circuit of balun to unbalanced voltages in the feeder.

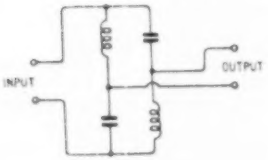


Fig. 7. The balun as a unit.

$$\frac{e_0}{e_1} = \frac{1}{\sqrt{[1 + (f_0/2\Delta f)^2]}} \approx \frac{2\Delta f}{f_0} \text{ when } 1 \ll (f_0/2\Delta f)^2$$

In television applications we are interested in a band of 3.5 Mc/s covering the sound and vision carriers. The maximum value of Δf is thus 1.75 Mc/s, so that the smallest value of $f_0/2\Delta f$ is 43.25/3.5 = 12.35.

The discrimination of the circuit against unbalanced signals in the feeder is infinite at the centre of the band and falls to about 22 db at the band edges in the worst case.

Circuit Values

The choice of L and C values for the circuit is very easy. For the conditions discussed, namely, $Z_B = Z_U$, only two conditions have to be met and these are $L/C = Z_1^2$ and $LC = 1/\omega_0^2$. Therefore, $C = 10^6/\omega_0 Z_U$ and $L = Z_U/\omega_0$ where $\omega_0 = 6.28$ times the mid-band frequency. The units are pF, μH, Mc/s and Ω.

As an example, if the frequency is 43.25 Mc/s and Z_U is 72Ω, we get C = 51 pF and L = 0.265μH.

Adjustment

Having computed the circuit values the proper values of capacitance should be used since capacitors can usually be bought with values sufficiently close to the correct ones. In any case, the values are such that they can easily be measured.

The inductances should be adjustable. Consider the LC network as a unit, Fig. 7, with two output terminals joined either directly or through a coaxial cable to the receiver. Join the two input terminals together and to a signal generator operating at the mid-band frequency. Adjust the inductance joined to the non-earthy output terminals for minimum output from the receiver. Reverse the output connections, so that the other inductance is joined to the non-earthy output terminal and adjust this second inductance for minimum output.

Adjustment is probably unnecessary when the proper dimensions of the coils have been determined. In production, an adequate balance is probably obtainable without individual adjustment once the proper winding has been determined.

This circuit has the great practical merit of being very simple and over the bandwidth of a television signal it gives a discrimination against an unbalanced signal of over 20 db, which is probably all that is needed. It has the disadvantage that it must be adjustable for different stations whereas it is possible to make a transformer which will cover the whole television band. As usual, every system has its advantages and disadvantages and, again as usual, the choice depends on the importance which is attached to each in individual circumstances.

APPENDIX

Star-delta Theorem

Referring to Fig. 5 we designate the delta impedances by the terminal numbers between which they are connected and the star impedances by the terminal numbers to which they are connected. Then

$$Z_1 = Z_{12}Z_{13}/Z$$
$$Z_2 = Z_{12}Z_{23}/Z$$
$$Z_3 = Z_{13}Z_{23}/Z$$

where $Z = Z_{12} + Z_{13} + Z_{23}$.

Wireless Servicing Manual

THIS book has long since become established as the radio serviceman's friend and adviser, dealing as it does with the location and cure of the innumerable faults which can develop in broadcast receivers and their associated equipment. Radio amateurs, as well as professionals, however, have also found it invaluable in solving many of the problems that arise in experimental and constructional work.

This eighth edition has been revised and brought fully up to date; in particular the chapter on television receiver defects has been completely rewritten. Apart from domestic sets, short-wave receivers and converters are covered, and there is also a special chapter devoted to servicing with the cathode-ray oscilloscope. Methods of ganging receivers of both the "straight" and superhet types are given in detail, and the all-too-common problems of hum and distortion are treated with the same thoroughness.

A useful appendix contains much information of the kind constantly required in everyday servicing work, and a very complete index has been provided to give the book added value for reference. "Wireless Servicing Manual" can be obtained from our Publishers, price 12s 6d (postage 5d), or from any bookseller.

Technical Instruction for Marine Radio Officers

ONE important feature of this book which will appeal to radio officers is that it provides a complete theoretical course for the P.M.G.'s certificates in radiotelegraphy and radiotelephony, together with a syllabus and a specimen examination paper. Originally published as the "Handbook of Technical Instruction for Wireless Telegraphists," it is now available in a ninth, revised, edition, the title having been changed in recognition of the fact that the sphere of activity of the marine radio officer has grown considerably in the course of the years. Nevertheless, the main object of the book remains unchanged—to provide simple instruction in general radio principles and practice for all those who operate marine wireless equipment.

Revision has been carried out on an ambitious scale. New chapters have been added on the cathode-ray oscilloscope, on e.h.f. generators such as the magnetron, and on radar recognition systems; whilst descriptions of new apparatus put in service since the war replace those of older equipment now out of production. The Instruction can be obtained from our Publishers, price 60s (postage 9d), or from any bookseller.

Simple Valve Voltmeter

An Inexpensive Instrument with Good Zero Stability

By S. W. AMOS,* B.Sc.(Hons.), Grad.I.E.E.

DURING the past year the author has constructed and used a number of simple types of valve voltmeter consisting of a detector followed by a d.c. amplifying stage. One result of this experience has been to underline the importance of two properties which are not sufficiently stressed in constructional articles on such instruments, yet are as important as accuracy of calibration, good linearity and high input impedance. These properties are zero stability and zero error and may be defined as follows:—

Zero Stability. The instructions for operating a valve voltmeter usually recommend that the zero control be operated to adjust the reading to zero, with the input short-circuited, and after the instrument has been switched on for at least several minutes. The instrument is then ready for use. With a perfect instrument the reading for no signal input will remain steady at zero without further adjustment of the zero control no matter how long the instrument is in use. This ideal is difficult to obtain, and there is usually some fluctuation of the no-signal reading. The steadiness of the no-signal reading is known as the zero stability.

Zero Error. After the zero control has been operated to adjust the no-signal reading to zero, there should be no change in reading when the range switch is operated. In this article such a change in reading is termed zero error and, by good design, can be eliminated completely.

Time Saving

If zero stability is poor the no-signal reading must be adjusted to zero before every reading. It is usually necessary to short-circuit the input before adjusting the control, and this may involve disconnecting the input terminals or the probe contact from the source of voltage under measurement. If the reading obtained on re-connecting the voltmeter in circuit is too small or too large, the range switch must be operated, and if the instrument has appreciable zero error, this will change the no-signal reading, necessitating a further adjustment of the zero control and disconnection of the input. With a poor instrument, therefore, it may be necessary to adjust zero before every reading and after every alteration of range.

To show how large the change in no-signal reading may be, the following figures were noted for two of the valve voltmeters used during the tests. In one model the no-signal reading varied over 30 per cent of full-scale reading during a period of several hours and never reached stability; in another, when zero was adjusted on one range, a reading of 50 per cent of full-scale deflection was obtained on switching to another range.

By combining the best features of all the instruments tested in a single valve-voltmeter circuit, an instrument was produced having good zero stability, no zero error and a satisfactory performance in other respects. It is a simple two-valve instrument incorporating a robust 0 – 0.5 mA moving-coil meter and can be built using ex-Government components for less than £4. Details of the performance are given below.

1. After an initial warming up period of 10 minutes, the no-signal reading of the instrument does not vary by more than 2 per cent of full-scale deflection no matter how long the instrument is in use and is unaffected by fluctuations in mains voltage. This is the maximum no-signal variation and occurs on the most sensitive range; on other ranges the zero stability is better.

2. If the no-signal reading is adjusted to zero on the most sensitive range, there is no change in reading on switching to the less sensitive ranges, i.e., there is no zero error.

3. The input resistance is unaffected by range switching and, in the particular circuit described, is approximately 3.8 MΩ. If a particularly high input resistance is required, a value of over 5 MΩ can be obtained by a slight sacrifice in zero stability. The input capacitance depends on the construction of the detector circuit, and by careful probe design can be reduced to approximately 5 pF.

4. The model described gives a full-scale deflection for 2.5, 25 and 250 volts peak input, but intermediate ranges can easily be added if desired. The range switch is a single-pole type, and, for each additional range, only one extra fixed resistor and one extra contact on the switch are required. The range resistors must be accurate, but are not of high value, the highest being 200 kΩ.

5. The linearity of the instrument is illustrated by the curves of Fig 1; it is good except near zero on the most sensitive range. Non-linearity on this range as a whole is less serious than might be expected, because full-scale deflection corresponds to a higher input voltage (2.5 volts peak) than is usual for the most sensitive range of a valve voltmeter. This insensitivity must be accepted to obtain high zero stability with such a simple circuit, but it has the advantage that no calibration curve is necessary on any of the ranges and no alteration to the meter scale is required.

The basic circuit of the valve voltmeter is given in Fig 2. It contains a signal diode V1 direct-coupled to the grid of a cathode follower V2. The meter M is connected between the cathode of V2 and that of V3, which is a similar triode with the

* Engineering Training Dept., B.B.C.

same value of cathode load. The grid of V_3 is connected to a diode circuit which is similar to that feeding V_2 and completes the symmetry of the circuit.

When a signal is applied to V_1, the diode conducts and a negative potential equal to the peak value of the applied signal is developed at the diode anode. This is applied to the grid of V_2, reducing the valve current and causing the cathode potential to fall, with the result that the meter shows a reading. Similarly if a signal is applied to V_4, the grid of V_3 is driven negative and the meter gives a reading in the opposite direction. If the same alternating signal is applied to both diodes, the same value of steady negative potential is applied to the triode grids and the meter gives no deflection. This circuit thus measures the *difference* between the peak values of the signals applied to V_1 and V_4. Normally, however, no signal is applied to V_4 and the meter indicates the peak value of the signal input to V_1.

Neutralizing Supply Fluctuations

The zero stability of this circuit can be appreciated from the following argument. The simplest type of d.c. amplifier for a valve voltmeter consists of a single valve with a meter in the anode circuit, and possibly a circuit for backing off the standing anode current. The zero stability of such a circuit is poor because the anode current varies with changes in h.t. and l.t. supply volts. An improved performance is obtained with a double valve circuit, the meter being connected between the anodes; the anode currents now rise or fall together with variations in h.t. and l.t. supply. This circuit is capable of good zero stability provided the two valves have identical characteristics, but difference between the valves will cause the no-signal reading to wander.

In Fig. 2, both triodes have considerable current feedback due to the large value (47 kΩ) of cathode resistor; this effectively equalises any differences that may exist between the characteristics of the valves, and the two valves need not necessarily be identical. The cathode currents, and hence cathode potentials, rise and fall to the same extent with variations in h.t. or l.t. supply, and provided the cathode potentials are initially the same the meter does not respond to such variations.

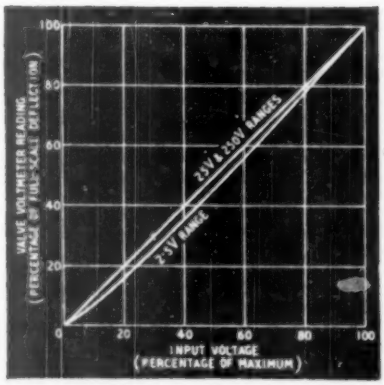
Fluctuations in no-signal reading can result if the grid-circuit resistance is increased beyond a certain limit. For the particular valve used (6SN7), the zero stability is good, if the resistance is 10 MΩ, or less.

Fluctuations in no-signal reading can also be caused by the diode detector. A diode with a high-value load such as is used in valve-voltmeter circuits gives an output of approximately 1 volt even with no signal input; this output is caused by arrival at the anode of electrons released from the cathode with appreciable initial velocities. This standing output varies and gives rise to changes in no-signal reading; it is also responsible for considerable zero error in valve voltmeters. Changes in no-signal reading due to this cause are eliminated in this instrument, as in others, by use of the balancing diode V_4 in the same envelope as V_1 and with the same load value. Any variations in standing output from V_1 are accompanied by similar variations in output from V_4; these outputs are applied to V_2 and V_3 in the same sense and thus produce no meter deflection.

The magnitude of zero error depends on the method of range switching. If range switching is carried out by a potential divider in the diode load circuit, the fraction of the standing output applied to the amplifier is varied by the range switch and zero error is inevitable unless a balancing diode with a similar potential divider is used. This involves two sets of close-tolerance resistors and two switch units; for this reason the method was rejected.

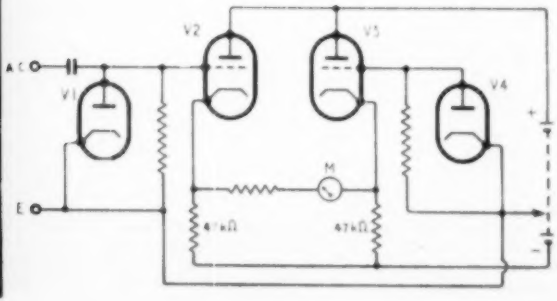
Range-switching is effected in this instrument by a single-pole switch which alters the resistance in series with the meter. When the zero control has been adjusted until there is no current in M, alteration of the resistance in series with M cannot change the reading, and there is thus no zero error. It is best to adjust zero on the most sensitive range.

On the least sensitive ranges V_2 must be capable of accepting large inputs without distortion and this is only possible if the p.d. across the cathode load for no diode input signal (known as the standing p.d.), exceeds the maximum input to V_2. If there is no potential divider between the output of V_1 and the input to V_2, the maximum input to V_2 would be 250 volts for a 250-volt peak input signal to V_1. This implies a p.d. across R_6 of at least 250 volts and an overall h.t. supply of the order of 400 volts. The necessity for so high an h.t. supply is avoided in this instrument by including a fixed potential divider R_1R_3 between V_1 and V_2 which reduces the input to V_2 to 0.4 of the diode output.



Left: Fig. 1. The calibration curves show good linearity.

Below: Fig. 2. Basic circuit of valve voltmeter.



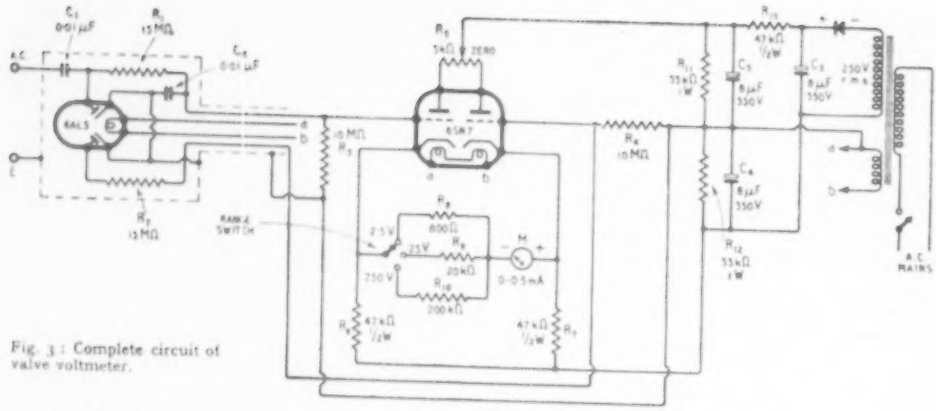


Fig. 3: Complete circuit of valve voltmeter.

i.e., 0.4 of the peak input signal. A similar divider R_3R_4 is included between V4 and V3 to preserve the balance of the circuit. As shown in Fig. 3, the potential divider R_1R_2 is also part of the filter R_1C_2 which ensures that only the steady output of the diode is applied to V2. With this circuit arrangement the greatest input that V2 must accept is 100 volts (for a 250-volt peak input) and a standing p.d. of 130 volts across R_6 is adequate to ensure that V2 can accept this without non-linearity.

When an input signal is applied to V1, the grid of V2 is driven negative and the cathode potential also changes by the same amount. Thus the e.m.f. acting in the cathode circuit is aV_{in} where V_{in} is the peak applied signal and a is the attenuation due to R_1 and R_2. The effective resistance in the meter circuit is $2/g_m + R_m + R$ where g_m is the working mutual conductance of each valve, R_m is the meter resistance and R is the external resistance in series with the meter. Thus the meter current I is given by,

$$I = \frac{aV_{in}}{2/g_m + R_m + R}$$

from which

$$R = \frac{aV_{in}}{I} - \frac{2}{g_m} - R_m$$

From this expression the value of R can be calculated for any input and any meter. To obtain the value of R for a given range, V_{in} is put equal to the maximum reading for the range and I to the current for full-scale deflection.

For the particular model constructed $a = 0.4$, $I = 0.5$ mA, $g_m = 2$ mA/V and $R_m = 200$ ohms. $\therefore R = 800\,V_{in} - 1200$.

For large values of V_{in}, R may be taken as $800V_{in}$. For example when $V_{in} = 250$ volts, R is within 1% of 200 kΩ and when $V_{in} = 100$ volts, R is within 2% of 80 kΩ. For low values of V_{in}, the second term is important. For example, if $V_{in} = 2.5$ volts, $R = 2000 - 1200 = 800$ Ω. Notice that if R is made equal to zero, $V_{in} = 1.5$ volts. For the particular values of a, g_m, I etc., this is the maximum sensitivity of which the circuit is capable.

The value of R for a required range depends on a, the ratio of R_2 to $R_1 + R_2$; if wide-tolerance resistors are used for R_1 and R_2 and the value of a is not known accurately, for each range R can be made up of a wide-tolerance fixed resistor in series with a pre-set potentiometer which is adjusted on a known input to give correct calibration.

The input resistance of the instrument depends almost entirely on the value of R_1 and is approximately 3.8 MΩ (measured) for the circuit of Fig. 3. If R_1 is increased to give a greater input resistance (R_2 remaining fixed) the sensitivity falls and the values of R must be altered to preserve calibration on the higher ranges. If R_1 and R_2 are increased in the same ratio, input resistance is increased and calibration is unaffected, but zero stability suffers. A reasonable performance is obtained, however, with $R_1 = 30$ MΩ and $R_2 = 20$ MΩ, the input impedance being over 5 MΩ.

The anode current of each triode with no input signal is about 3 mA, the p.d. across the 47 kΩ cathode resistor being 130 volts. The p.d. between anode and cathode must be reasonably high to ensure that the valve can pass 3 mA without taking grid current (this would destroy sensitivity). An anode-cathode p.d. of 130 volts is satisfactory and is obtained by returning both grid circuits to the midpoint of two 33 kΩ fixed resistors R_{11} and R_{12} in series across the h.t. supply. The cathode potentials rise to a value slightly above that of the grids, the net grid-cathode potential biasing the valves so that they supply 3 mA each. The two triodes and the potential divider consume a total of about 14 mA at 260 volts and are supplied by a half-wave circuit including a mains transformer delivering 250V r.m.s., and a 25-section selenium rectifier. The simple smoothing circuit R_{13} C_3 C_4 is quite adequate.

The zero control is a 3 kΩ potentiometer connected in the anode circuits of the two triodes and arranged so that it alters the anode potentials differentially.

No constructional details of the instrument are given because layout is not in any way critical; and it was thought, therefore, that interested readers would prefer to design their own chassis. If the instrument is intended mainly for use at audio-frequencies a diode of the 6H6 type may be used and can be mounted with all the other components on a chassis. For radio-frequency measurements, a probe, connected to the main chassis by a screened four-wire cable, is recommended. A convenient valve to use, because of its small size, is the 6AL5.

Amateur Radio Exhibition

Specialized Equipment for the Experimenter

THE focal point of this exhibition, to which all visiting amateurs were sooner or later attracted, was the stand of the organizing body, the Radio Society of Great Britain. Here the very latest 70-cm equipment made and used by members was exhibited and some of it held a special interest for it showed that, contrary to popular belief, communications equipment for this frequency could be made to work quite satisfactorily without "plumbing" of any kind, but by using readily obtainable valves and components. Many of the parts were actually to be found on stands of firms showing at this exhibition.

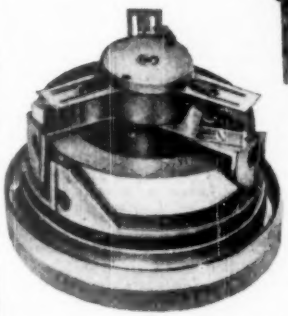
On the opening day it seemed that the general pattern would not differ greatly from that of past years, but by the second day a new interest made its appearance. This was a demonstration, over a closed circuit in the hall, of television by the British Amateur Television Club. It was a 300-line-50-picture system, and the transmitter used an R.C.A. Type 5527 Iconoscope tube which, it is understood, is obtainable in this country for about £25.

Some interesting demonstrations were given by the Engineering Department of the Post Office, the most impressive being a quartz-crystal controlled oscillator using an Essen ring crystal. It consists of an annular ring of quartz, about 3in in diameter and 1in thick, with silver-deposited electrodes on its inner and outer surfaces, the whole being suspended by silk threads. Its fundamental frequency is 100 kc/s. The "Q" of the crystal is almost beyond accurate determination, being between 1 and 2 million, and its frequency stability is 2 parts in 10^8. This type of crystal is used for generating the standard frequency transmissions radiated by the Post Office station at Rugby for the N.P.L. The 5-Mc/s transmission must, therefore, be accurate to ± 0.1 c/s.

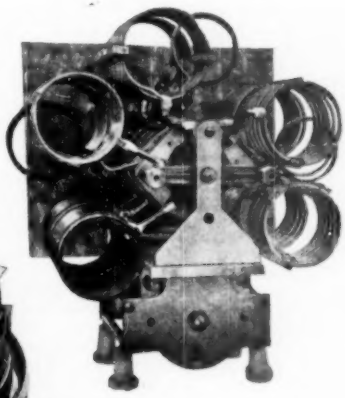
Another Post Office exhibit of particular interest to amateur transmitters was a demonstration of the effects of keying a radio carrier with and without an adequate key filter, the spread of the side bands being shown on an oscilloscope. Quite a simple capacitance-resistance filter confined the spread to a hundred or two cycles, while without it harmonics up to 3 kc/s were generated.

As most amateurs take a pride in the appearance of their station, it was perhaps not so surprising to find a large assortment of chassis, cabinets, racks and fittings in the show. A new note was struck by the Widney-Dorlec metal cabinets shown by C. H. Davis, as they are tailored to fit the apparatus, whereas it is generally necessary to make the equipment fit the cabinet. Telescopic slide rails for draw-out chassis in racks and cabinets were shown also by this firm. A design of cabinet that can be added to from time to time, using much of the original framework, was shown by Philpotts Metalworks, while Imhof had their customary extensive display of impeccably finished cabinets and racks.

The scarcity of general components at a show of this kind was a little disappointing, and two firms only had



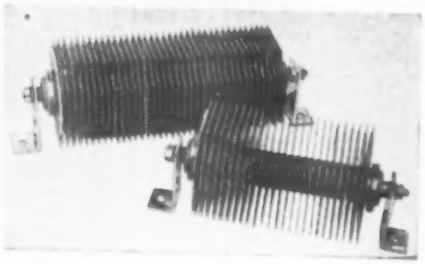
Below: Essen-ring quartz crystal for frequency stabilization of 100-kc/s oscillator. Demonstrated by Post Office Engineering Department.



Above: Five-range tank coil unit for 150-watt transmitter made by Q-Max Electronics.

Below: Two latest G.E.C. microphones, the BCS2381 moving coil (left) and the BCS2370 ribbon (right). The stands are the BCS2247.

The new Eddystone Model 740 inexpensive communications receiver shown by Webb's Radio.



Westinghouse full-wave selenium rectifiers, the HT53 (back) and HT52 (front) for 500-0-500V and 350-0-350V r.m.s. input respectively and 200 mA d.c. output.

really comprehensive displays. The Webbs Radio exhibit was one, and this included a well-represented range of Eddystone parts, while the other was Q-Max who included some very well-made transmitter tank coil assemblies in single and multi-band types, each incorporating a split-stator condenser, self-supporting anode coils, variable coupling coils and switching where appropriate.

Oliver Pell Control helped to extend the component display into the field of mains transformers and chokes, and they were ably supported by Woden Transformer Company with a range of potted types.

A minor surprise was to find E.M.I. Sales and Service showing a few components. They were grouped in a section devoted to exclusively amateur apparatus and comprised a big selection of i.f. transformers and some mains transformers. Here were seen also some 10½-in and 13½-in elliptical loudspeakers of 5 ohms impedance and an inexpensive nickel-plated hand-type carbon microphone.

Quality enthusiasts were catered for by the Decca Record Company in the form of their 12-in Duo-Centric loudspeaker which is said to have a flat response from 30 to 20,000 c/s. It has a 2-in diameter speech coil of 18 ohms impedance and will handle 10 watts if necessary.

It was a little disappointing to find so few valves this year, especially transmitting valves, and the visitor had to be satisfied with the very limited range shown by G.E.C., which consisted mainly of receiving types in the miniature series. One exception was a v.h.f. double tetrode, the TT17, but its price placed it beyond reach of the average amateur. Incidentally, some of the new miniatures could find application in the early stages of transmitters.

Rectifiers there were in abundance, but apart from the G.E.C. germanium crystal valve, they took the form of selenium or copper-oxide types shown by Westinghouse and Salford Instruments. Among the exhibits of Westinghouse, the HT2 and HT3 units were of particular interest, as they are rated at 350-0-350 V and 500-0-500 V r.m.s. input respectively and give 200 mA d.c. output as full-wave rectifiers. E.H.T. rectifiers and voltage-doublers and treblers for c.r. oscilloscopes and television sets were appropriately included by Westinghouse, as equipment of this kind holds considerable interest for a large body of amateurs.

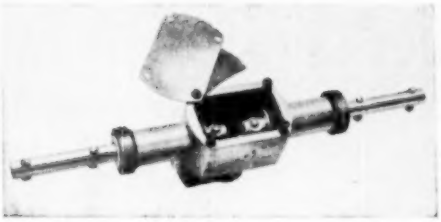
Whilst there was nothing outstandingly new in test apparatus, what it lacked in this respect it made up for in quantity. More than half the total number of firms exhibiting had something in the nature of a test set. Avo, as usual, had a very comprehensive display which included nine different types of the well-known Avometer. Sangamo-Weston showed two versatile instruments in the shape of the S75 multi-range set and the E772 Super Sensitive Analyser; Taylor had bridges, signal generators and a fine display of single-range pointer instruments suitable for rack-mounted transmitters and also for small portable sets; G.E.C. showed the Miniscope oscilloscope with its various accessories and E.M.I. had a range of frequency measuring sets introduced especially for the amateur station. There were some miniature absorption wavemeters on Q-Max and Webbs' stands, while Salford included a quartz crystal activity measuring set.

Three firms showed communications receivers this year. The BRT400 occupied the most prominent place on the G.E.C. stand and attracted considerable interest. This handsome receiver covers 150 kcs to 33 Mc/s, can be operated from mains or batteries and contains 14 valves. The bandwidth is variable in six steps from 500 c/s to 9 kc/s and it has a crystal filter.

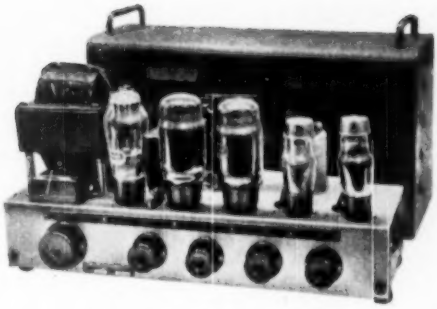
A set designed especially for the amateur bands is the Q5/10X communications receiver made by Q-Max. It covers the six amateur bands only between 1.8 and 30 Mc/s, including the awaited 21-Mc/s one, employs the double superheterodyne principle with the first i.f. at 5 Mc/s and the second at 465 kc/s. A crystal filter is fitted, also an "S" meter and a six-position selectivity switch giving bandwidths of from 200 c/s to 15 kc/s; there is also a 100 kc/s crystal calibrator and the price is just over £50.

A new and inexpensive communications receiver is the Eddystone Model 740, shown by Webbs Radio. This is an orthodox superheterodyne with the i.f. on 450 kc/s and its coverage is 485 kc/s to 30.6 Mc/s, in four overlapping bands. All-glass miniature valves are employed and despite the low price of under £30 it has all the usual communications receiver features of b.f.o., noise limiter, provision for "S" meter, r.f. and a.f. gain controls and bandspread.

Some unfamiliar types of aerial were seen on G.S.V.'s stand. One, which took the form of a cone surmounted by a disc, has been developed for wide-



Compact water-tight centre unit for dipole aerials shown by Telecraft. Ebonite bushes are used for the dipole rods and a rubber washer is fitted underneath the cover plate.



E.M.I. Sales and Service 20-W speech amplifier, the Model PA181. There is a model for rack mounting also.

band operation. Two models are available; one covers 400 to 1,200 Mc/s and the other 800 to 5,000 Mc/s. It is claimed to be an efficient radiator with low-angle, omni-directional characteristics. Various forms of broad-band ground-plane aerials, and a corner reflector for 420 Mc/s, completed an interesting display.

A neat and compact centre unit, designed primarily for television aerials, but equally applicable to amateur aerial assemblies, was shown by Telecraft. Described as a "dipole feeder box," it is made of die-cast light alloy and all inlet points, such as for the dipole elements, cross arm member and cover plate, are fitted with waterproof seals.

Modulation amplifiers form an important part of every amateur transmitter and for many purposes the commercially made gramophone amplifier answers the purpose admirably. A wide range tone control is most useful, especially for DX operation. This facility was provided in the models shown by E.M.I., their Type PA181, rated at 20 watts output, has an input (microphone) sensitivity of 0.1 V and is designed for 15-ohm microphones. The circuit comprises two stages of voltage amplification, bass and treble tone controls and a push-pull output stage using KT66s in class AB1.

A gramophone amplifier, also with provision for a microphone input, is the Decca model AP/IX. Its response is flat from 20 to 20,000 c/s and it gives 7 watts output using a pair of PX25s in a class A push-pull and with negative feedback. A wide-range tone control is incorporated.

Self-Tuning Car Radio

Automatic Programme Selection by Foot-operated Switch

IN order to simplify programme selection on car radio receivers the Delco Radio Division of General Motors in America have developed a tuning system which is possibly the nearest approach to the automatic yet evolved. The tuning system of the radio set is actuated by a spring motor which, when set in motion, sweeps from one end to the other of the waveband. When the tuner reaches the end of its travel an electrically operated solenoid mechanism returns it, almost instantaneously, to the beginning, at the same time rewinding the motor spring.

Immediately a radio carrier is encountered the mechanism is stopped and the receiver locks in on the station. It is claimed that the lock-in takes place within 1 kc/s of the carrier frequency. If the programme so selected by the set holds no interest the station-seeking process can be set in motion once again merely by depressing a conveniently placed foot-switch.

It would obviously be impracticable for the tuner to be arrested by every carrier intercepted, as the system would be halted every 8 or 10 kc/s throughout the waveband covered. An over-riding control is, therefore, incorporated which establishes a minimum receiver sensitivity so that carriers of a certain strength only actuate the stopping mechanism. This control can be set to operate on any desired strength of signal, from one almost obscured by local electrical noise to the most powerful likely to be encountered in normal use.

The system of radio networks employed in America favours continuity of a programme when travelling long distances as it ensures the best possible reception under all conditions. But the ability to change stations so readily, and with such perfect safety when the driver is alone in the car, is a feature that should have a great appeal to those who like to have the receiver working when negotiating crowded thoroughfares or driving along difficult, twisty roads where the driver cannot afford to take his attention off the road for a moment.

The system has so far been applied to single-waveband receivers only, but there seems no reason why it should not be extended to multi-waveband sets. However, in order to avoid undesirable complications a manual wave-change switch might have to be incorporated.

Sidelights on

Loudspeaker Cabinet Design

(Concluded from page 385 of the previous issue)

Motional Impedance and Acoustic Output in Vented Cabinet Systems

By D. E. L. SHORTER,* B.Sc.(Eng.), A.M.I.E.E.

IN the first part of this article it was seen that although an "infinite baffle" type cabinet of ample volume is often regarded as the ideal mounting, the full potentialities of such a system cannot always be realised in practice.

Consider now the case of a vented cabinet. Here, an auxiliary sound outlet is provided in the form of an aperture which, in conjunction with the cabinet volume, forms a Helmholz resonator tuned to some frequency near the lower end of the band to be covered by the loudspeaker. Such an arrangement possesses the advantage that the acoustic impedance presented to the cone at low frequencies is relatively high, so that the cone velocity, and hence the motional impedance, are restricted. The electrical mismatch referred to in the last section is therefore much less serious than in the case of a closed cabinet. This feature of the vented cabinet, coupled with the extra sound output obtainable from the vent, make it possible to maintain a uniform low frequency response down to the limit imposed by the size of the cabinet and the constants of the unit. It may, however, be remarked in passing that because the difference in performance between the closed and vented cabinet systems depends so much on the difference in electrical impedance characteristics, no general comparison between the two can be made without taking account of the efficiency of the cone unit employed and the output impedance of the amplifier used. This article is concerned only with the conditions of high unit efficiency and low source impedance (less than one third of the minimum loudspeaker impedance) met with in modern high-quality equipment.

The general properties of the vented cabinet are treated in existing technical literature and need not be discussed here. It may be well, however, to mention certain special features which must be borne in mind if the best results are to be obtained.

The normal mechanism of electrical damping of a loudspeaker depends on the e.m.f. generated by the motion of the speech coil. This e.m.f. provides a circulating current via the output of the driving amplifier, and any energy left stored in the system at the cessation of the incoming signal is thus dissipated. However, at the frequency of the vent resonance (i.e. the resonance between the acoustic inductance of the vent and the acoustic capacitance of the cabinet volume), the motion of the speech coil is so small that no appreciable electrical damping can take place. The energy dissipated by mechanical resistances and by the radiation of sound is generally small, so that the vent resonance, on which the maintenance of the bass response depends, is quite lightly damped. This condition, which shows itself in a relatively sharp cut-off in response at the lower end of the frequency band, inevitably involves bad transient response and may lead to "boomy" quality. Fortunately, the tolerance of the ear for resonance effects increases rapidly with decreasing frequency and it seems to be a safe rule, for the highest quality of reproduction, to make the vent resonance frequency 60 c/s or less. Where this requirement cannot be met, the effect of closing the vent altogether should be determined by ear. Male speech is probably the best programme material for this test. In some cases it may be found that the loss of bass occasioned by the closing of the vent is in fact the lesser of two evils.

Impedance Tests

Some caution is necessary in interpreting the results of electrical impedance measurements on a vented cabinet system. Impedance measurements are of great assistance in setting the vent resonance to the desired frequency, while many of the standing wave effects can be shown up clearly by balancing out the static component in the manner described in the first part of this article. However, since the cone is not the sole source of sound, the simple relationship between motional impedance and acoustic output existing in a closed cabinet does not hold in this case. To illustrate the argument, let us draw the equivalent electrical circuit, shown in Fig. 6. This consists of the circuit of Fig. 4 extended by the addition of R_V, representing the radiation resistance of the vent and L_V, the acoustic inductance of the vent plus the effects of its radiation reactance. Let f_V be the frequency of the vent resonance, i.e. the resonance of L_V with C_{AB}, and assume for the sake of simplicity, that the cone resonance frequency is the same. Below f_V the series combination L_VC_V appears as a capacitance and the parallel combination L_VC_{AB} as an inductance; and the overall effect is to produce a series resonance at some frequency f_1 in this region. Above f_V, L_VC_V appears inductive and L_VC_{AB} capacitive; and a second series resonance appears at some

* Research Dept., B.B.C. Engineering Division.

frequency f_r. The resonances at f_1 and f_2 are responsible for the characteristic double hump in the electrical impedance frequency characteristic of a vented cabinet and, it may be noted, are subject to the circuit damping represented by R_s.

It is very tempting to assume that because the addition of a vent has produced an impedance hump at some frequency f_1 below that of the cone resonance, the frequency range of the loudspeaker has been correspondingly extended. To see whether or not such a hope is justified it is necessary to consider the phase relationship between the alternating air currents which flow in the cone and vent apertures and which are represented in Fig. 6 by I_C and I_V respectively. I_C originates at the back of the cone and I_V must therefore be reversed in phase with respect to I_C if the acoustic output of the vent is to reinforce that from the front of the cone. Consider now the parallel resonance circuit L_VC_V for which I_C represents the total current and I_V the current in the inductive branch. At f_v, the frequency of resonance, I_C and I_V are approximately in quadrature; above f_v the desired antiphase condition is approached, but below f_v the two currents become more nearly in phase. This reasoning, which is independent of the values of L_C and C_C and therefore holds good whether or not the cone and vent resonance frequencies are equal, shows that f_v represents a turning point in the phase relationship between the cone and vent outputs. The resonance at f_2, which is above f_1, indicates an increase in the sound output of the system while that at f_1, which is below f_v, indicates a decrease. Thus the effective frequency range of the system can hardly be expected to extend to f_1.

Before leaving the circuit of Fig. 6, it may be pointed out that by the reasoning already applied in the case of E_{LC} in Fig. 4, the variation of the voltage E_{LV} with frequency represents the frequency

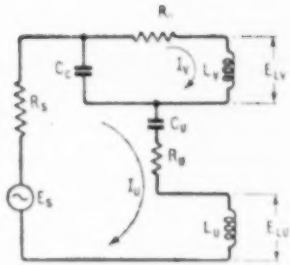


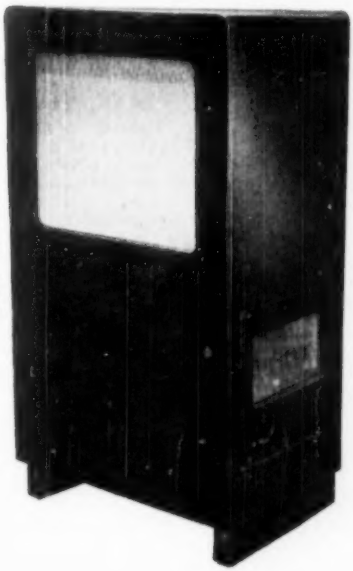
Fig. 6. Equivalent electrical circuit of vented cabinet loudspeaker at low frequencies.

characteristic of the sound emanating from the vent alone. Care must be taken, however, not to carry the analogy too far. To take the voltage across an inductance, instead of the current through it, is a convenient way of introducing a factor proportional to frequency; the artifice is however limited to giving frequency characteristics for a given set of circuit constants. E_{LC} and E_{LV} do not represent actual sound levels and cannot be directly added to give the total output from the system.

Cabinet Volume

In designing a vented cabinet, the first quantity to be fixed is usually the vent resonance frequency f_v, since this roughly determines the low frequency range of the system. Although the value of the product L_VC_V is thus automatically decided, the performance of the system is not yet fixed; the response characteristic for the first octave or so above f_v depends very much on the ratio L_V/C_V. Thus, with a large cabinet and a large vent opening (C_V large, L_V small) the response can rise to a peak in the bass while a small cabinet with a small vent (C_V small, L_V large) will give much the same effect

Vented cabinet for 15-in coaxial monitoring loudspeaker, with back removed to show the damping partition. The vent opening is in the base of the cabinet.



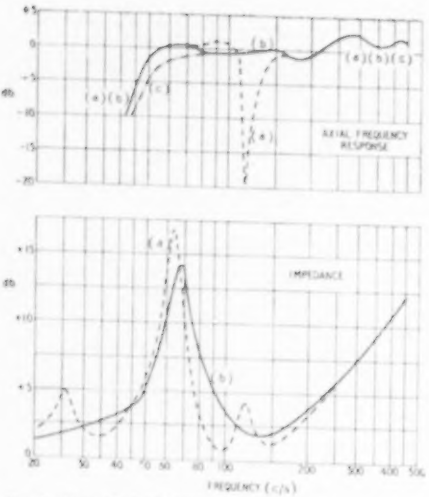


Fig. 7. Free-air axial response of a vented loudspeaker and corresponding impedance characteristic (a) inner surface of cabinet lined in conventional manner (b) with the addition of felt partition giving optimum damping (c) excessive damping in partition.

as a completely closed cabinet, i.e., there may be a bass loss. Between these two extremes, there will be a pair of values for L_V and C_V which gives the best approximation to a flat frequency response. The cabinet volume required for this last condition depends on the efficiency of the cone unit and the output impedance of the driving amplifier; a practical example will be given later to show the type of result that can be obtained.

It will thus be seen that no spectacular reduction in the size of cabinet required for a given low-frequency response can be obtained by simply raising the value of L_V. To be on the safe side, it is better to work out the volume of a new design on the basis of a plain (i.e., unflanged) vent of area approaching that of the cone itself[1], even though the vent to be used finally may be somewhat smaller.

Many of the points discussed in the foregoing paragraphs can be illustrated by the example of a vented cabinet designed for use with a 15-in. coaxial unit for high quality studio monitoring. A photograph of the experimental prototype appeared in the first part of this article; two views of the final model produced from this by the B.B.C. Designs Department are shown on the previous page. Fig. 7 gives the free-air axial frequency response and impedance characteristics. As in the case illustrated in Fig. 1, the output impedance of the driving amplifier was low (in this instance, about ⅛th of the minimum loudspeaker impedance). The impedance characteristics show, to a decibel scale, the variation in voltage appearing in the speech coil fed with constant current, no attempt being made in this case to balance out the static component.

The dotted curves of Fig. 7(a) show the performance of the loudspeaker when the cabinet was lined with kapok quilt and carpet felt and the internal space left free. In this condition, a serious internal resonance, the effect of which can be seen on the impedance characteristic, occurs just below 120 c/s. The full line curves (b) show how this resonance was suppressed by introducing into the cabinet a partition having a window about 170 sq. in. in area covered with three layers of quarter-inch carpet felt. The position of this window is indicated in the photograph by dotted lines. It will be seen that the damping partition introduced to remove the 120 c/s resonance does not seriously affect the frequency response elsewhere in the pass band of the system, although the smaller of the two remaining humps in the impedance characteristic, which lies outside the pass band, is suppressed altogether. The quantity of material used on the damping partition, while not critical, must not depart too far from the optimum; the chain dotted curve of Fig. 7(c) shows the effect upon the frequency response of using too many layers of felt between the two parts of the cabinet. In this particular design, the cone unit and vent are respectively above and below the division so that the reponse obtained with a very high impedance partition naturally tends towards that of the top compartment alone acting as a closed cabinet.

The volume of the cabinet of Fig. 7 was restricted by considerations of space to 10½ cu. ft. The response was not required to rise at the bass and it was therefore possible to make the acoustic inductance of the vent relatively high and to keep the resonance frequency low. The radiation from the vent is made just sufficient to maintain the response curve almost level down to the cut-off point and the design thus represents the optimum for the particular set of conditions in which it is used.

It should be noted that the fall in response below 50 c/s is quite sharp and on a transient signal, the system "rings" in the region of cut-off; but at this low frequency the result is not offensive to the ear.

The cabinet of Fig. 7 has passed a number of subjective tests involving a direct comparison between original and reproduced sounds and the satisfactory performance indicates that a vented enclosure is capable of doing justice to the best loudspeaker units at present available.

[1] "Vented Loudspeaker Cabinets," by C. T. Chapman, Wireless World, October, 1949.

Register of British Manufacturers

THE 1950-51 edition of the "F.B.I. Register of British Manufacturers," the standard work of reference on British goods and their manufacturers, is now available. This new edition has more than 1,000 pages, and contains a classified buyers' guide listing in alphabetical order 3,000 products and services (showing under each heading the British firms that supply them). In another section are the postal and telegraphic addresses of all members of the Federation of British Industries, their main products and, in many instances, details of home and overseas branches and agencies. An alphabetical list of brand and trade names is also given.

Published for the Federation jointly by Kelly's Directories and our Publishers, home inquiries for copies should be addressed to Kelly's Directories Ltd., 186, Strand, London, W.C.2, and overseas inquiries and those from the book trade should be made to F.B.I. Register, Iliffe & Sons, Ltd., Dorset House, Stamford Street, London, S.E.1. The price is £2 2s.

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Their electrical characteristics, dimensions and base connections are identical to the American Counterparts bearing the same type number.

NOTE: Some American Manufacturers code these valves

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Type VR75/30

Minimum starting voltage	105 volts
Nominal operating voltage	75 volts
Minimum operating current	5 mA
Maximum operating current	40 mA

List Price **17/6**

Type VR105/30

Minimum starting voltage	135 volts
Nominal operating voltage	105 volts
Minimum operating current	5 mA
Maximum operating current	40 mA

List Price **17/6**

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Minimum starting voltage	185 volts
Nominal operating voltage	150 volts
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This model incorporates the famous Acos "Filtercel" insert giving extreme sensitivity and high fidelity. Response is substantially flat from 40-6,000 c.p.s. The microphone is vibration and shock proof and is not affected by low frequency wind noises. Two alternative mountings are available for the MIC 22 head :—

MIC 22-2 is supplied as a complete unit incorporating an attractive desk stand with cable side entry.

MIC 22-1 is for fitting to any British or American type standard floor stand and can also be used as a hand microphone.

PRICE £6. 6s. *(Either Model)*

TYPE MIC 16

Incorporates the Acos Floating Crystal Sound Cell giving a response substantially flat from 30-10,000 c.p.s. Performance is unaffected by vibration or shock and low frequency wind noise. As in the case of the MIC 22, two alternative mountings are available for the MIC 16 Head :—

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WORLD OF WIRELESS

Viewers Now 511,000 • Amateurs' Charter • Festival Station • U.S. Uproar Over Colour

Half a Million Viewers

TELEVISION licences in the U.K. passed the half million mark during October. At the end of the month the total was 511,150, an increase of 40,350 during the month and 322,800 on the October, 1949, figure. The number of "sound" licences in force was 11,805,700, giving a grand total of 12,316,850, an overall increase of 192,600 during the previous twelve months.

Australian Television

WE learn from a report in our associated journal *Wireless Trader* that standards for the projected television stations in Australia have now been fixed. As in the "European" standard, details of which were given last month, there are to be 625 lines per picture with interlaced scanning, the picture aspect ratio will be 4 : 3, negative picture modulation (black level 75 per cent of carrier) will be employed, and frequency modulation used for sound.

Vestigial sideband transmission in a channel of 7.5 Mc/s within the 181.5 to 204 Mc/s bands will be employed.

The power of the first station at Sydney will be 5 kW, vision, and 2.5 kW, sound.

Amateurs' Freedom

WHEN opening the R.S.G.B. Amateur Radio Exhibition, which is reviewed elsewhere in this issue, the Managing Editor of *Wireless World*, referring to the late Lord Derby as "the father of amateur radio," said that had it not been for his attitude towards the amateur when, as P.M.G., he introduced the first Wireless Telegraphy Bill in 1904, it is quite conceivable that private experimental licences might never have been granted.

Lord Stanley, as he then was, in introducing the second reading of the Wireless Telegraphy Bill, addressed the House with these words, which Mr. Pocock quoted:—"The class with whom I have the greatest sympathy are those who wish to go in for experiments in this science, and I have been able to frame a clause which will give absolute freedom in that direction, merely requiring registration on the part of those who wish to engage in experiments. In a matter of this description the House will doubtless desire that the Act should be administered as liberally as possible, and I shall certainly do my best in that direction. For what it is worth I will give an undertaking that no request for a licence for experiments shall be refused unless the refusal has been approved by me personally."

Festival Amateur Station

DURING the summer of 1951 a mobile version of the Festival of Britain exhibition on the South Bank in London will visit four of the great inland cities of Great Britain where, among the 5,000 odd exhibits, an amateur radio transmitting station will be set up and operated by local amateurs.

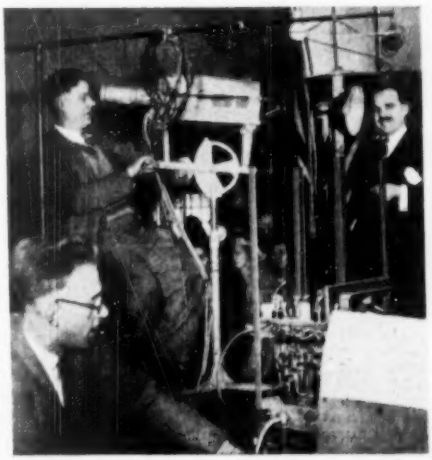
The cities to be visited and the dates concerned are:—

Manchester, May 4th to 26th.
Leeds, June 23rd to July 14th.
Birmingham, August 4th to 25th.
Nottingham, September 15th to October 6th.

The transmitting station will have its own call sign and a QSL card is being designed especially for the occasion.

Up-to-date equipment is to be supplied by the radio industry and the station will be enclosed by glass so that while visitors can see, and hear—by means of external loudspeakers—what is going on, the operators can work undisturbed.

The full co-operation of local amateurs is needed to ensure the success of this enterprise, and an amateur in each town—in whose name the licence will be taken out—will be responsible for maintaining a rota of operators to man the station. An announcement will be made on this matter at a later date.



CLOSED CIRCUIT television transmission, using home-constructed gear, was demonstrated by members of the British Amateur Television Club during the recent R.S.G.B. amateur exhibition.

Colour Quandary

AS recorded elsewhere in this issue, it would appear that American opinion has crystallized strongly against the F.C.C. decision to adopt the C.B.S. frame-sequential system of colour television.

A temporary injunction to restrain the F.C.C. from enforcing its order for the adoption of the C.B.S. system was successfully brought before the Chicago Federal Court by R.C.A. and N.B.C. a few days before the C.B.S. was due to start regular transmissions. A correspondent in New York writes "This, of course, is just the opening gun on a long legal battle which will probably go all the way up to the Supreme Court, which may take years. Unless something unforeseen takes place, C.B.S. will be prevented from starting their colour broadcasts (except experimentally, of course). Meanwhile, R.C.A. and other manufacturers are working overtime trying to perfect their all-electronic systems." A description of the new General Electric system is given on page 443.

Engineers' Protest

THE recent announcement by the Durham County Council making membership of a professional body or trade union a condition of employment has called forth a statement from the Engineers' Guild—an association of chartered civil,

mechanical and electrical engineers.

In it the Guild states that to require that "professional engineers be members of a trade union or any other organization, apart from such as are recognized as conferring an appropriate professional qualification, constitutes an unwarrantable interference with their professional and personal freedom and is contrary to the interests both of the engineering profession and of the public which it serves."

Rutherford Memorial

ALTHOUGH the name of Lord Rutherford (1871-1937) is inseparably linked with the study of nuclear physics it was in the realm of wireless that he made some of his early studies. It is recorded that in 1896 he succeeded in transmitting signals over a distance of half a mile using a magnetic detector of his own invention.

To commemorate the work of Rutherford an appeal is made by the President of the Royal Society for donations to create a memorial fund. The committee set up by the Royal Society under the chairmanship of Sir Henry Tizard proposes that the memorial, for which £100,000 is the target, should take two forms:—

(1) Rutherford Scholarships tenable for three years, to be awarded to post-graduate students within the British Commonwealth for research in the natural sciences with a preference for experimental physics. A scholar will normally be required to carry out his research at an Institution in some part of the British Commonwealth other than that in which he graduated; and

(2) A Rutherford Memorial Lecture to be delivered at intervals at selected university centres in the British Commonwealth overseas, at least one in three to be given in New Zealand, where he was born.

Contributions should be sent to the Rutherford Memorial Committee, The Royal Society, Burlington House, London, W.1.

"*Long-range Television*"

IN the article under this heading which appeared in our last issue a line of type was inadvertently omitted from the paragraph following the sub-heading "Comparison with Ionospheric Data" on p.408. The paragraph should read:—

"It is not feasible to compare these results with any measured m.u.f. (maximum usable frequency) data, because no such charts are published, and there do not exist enough measured critical frequencies over this path on which to estimate the actual m.u.fs which prevailed. It is possible, however, to compare the results with the predicted m.u.f. for the path, as obtained from the world ionospheric contour charts, which are compiled on the basis of past measured data supplied by the world network of ionospheric measuring stations."

Ambulance Radio

MORE than fifty ambulances and vehicles for sitting patients are being equipped with Pye 15-watt transmitter-receivers by the Essex County Council in readiness for the inauguration of the Ambulance Service radio-telephone system early in the new year. The main 100-watt station (Pye PTC 300), working on 86.975 Mc/s and using a 120-ft aerial mast on Danbury Hill, will cover most of the county.

The transmitter and its standby set will be remotely controlled by land line from the Ambulance H.Q. at Chelmsford—a distance of about five miles.

B.B.C. Year Book

CAPITAL cost and running costs of a modern 150-kW broadcasting station, broken down to show the comparison between expenses on staff, equipment, maintenance, power, etc., are given in an article by R. T. B. Wynn, the B.B.C. Deputy Chief Engineer, in the B.B.C. Year Book, 1951. He is writing on the use of unattended multi-unit transmitters employing "electronic listeners" as a saving in manpower and reduction in running costs. The staff released from the tedium of monitoring are being employed for development work.

In the table of running costs for a transmitter operating for eighteen hours a day, power accounts for 41 per cent.; staff, 31 per cent and valve replacements, 14 per cent.

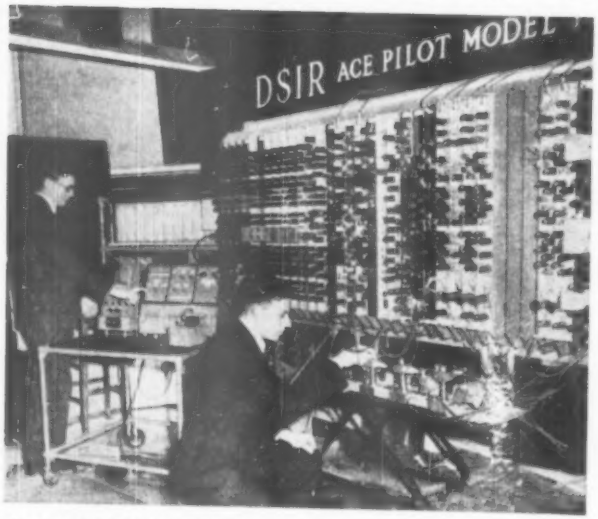
In addition to the usual numerous illustrations and programme matter there are a number of contributions dealing with various technical aspects of the corporation's activities both in sound and television. In the report on the work of the Engineering Division it is recorded that the total power of the B.B.C. stations employed for overseas transmissions is 3,140 kW. The transmitters radiating the Home, Light and Third Programmes account for 923.5, 661.55 and 78.45 kW respectively. The Year Book costs 3s 6d.

Television Receivers

THE long-awaited third edition of W. T. Cocking's "Television Receiving Equipment" is now available from booksellers, price 18s, or by post from our publisher, price 18s 8d. This edition, which has been completely revised and enlarged by some 50 per cent, gives an exhaustive and lucid description of each stage of a television receiver and deals with practical details of receiver design. Two of its twenty-three chapters are devoted to fault-finding and servicing.

PERSONALITIES

Sir Edward Appleton, G.B.E., K.C.B., F.R.S., has been awarded by the Royal Society one of the two Royal Medals for this year "for his work on the transmission of electromagnetic



ELECTRONIC COMPUTER.—This picture shows the Automatic Computing Engine designed and constructed at the National Physical Laboratory. Employing some 800 valves it will tackle any problem in arithmetic and carry out in a few minutes computations which take many months.

waves round the earth and for his investigations of the ionic state of the upper atmosphere." He recently received at the hand of H.R.H. Princess Elizabeth the Society's Albert Medal, the award of which was recorded in our July issue.

Major H. S. Prince (Retd.), M.B.E., M.Brit.I.R.E., Assoc.I.E.E., has been appointed Deputy Chief Inspector (H.Q.) in the Inspectorate of Electrical and Mechanical Equipment (Ministry of Supply) which carries with it an Assistant Directorship in the Engineers' Pool in the M.o.S. During the 1914-18 war he was attached to R.E. (Sigs.) and during and since the last war he was on several technical missions to the U.S.A. Between the wars he was with Burndept and later with Philips.

J. Vivian Holman, who is a director of Philco (Overseas), Ltd., and Philco (Great Britain), Ltd., has relinquished the executive posts he held with Radio and Television Trust, Ltd., and its subsidiary companies.

OBITUARY

J. Joseph, C.B.E., M.I.E.E., who founded Radio Instruments, Ltd., in 1922, and was a director of Aeronautical and General Instruments, Ltd., which took over R.I. in 1936, died recently at the age of 76. For some years prior to founding R.I. he was with H. W. Sullivan, Ltd.

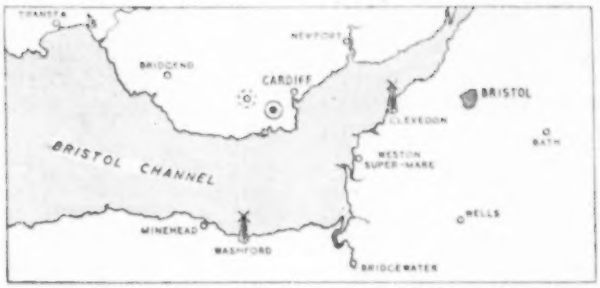
William D. Loughlin, the designer of the original "Q" Meter, who was chairman of the Boonton Radio Corporation of Boonton, New Jersey, of which he was founder, died on November 12th.

IN BRIEF

Amateurs' Exam.—The report of the City and Guilds examiners on the Radio Amateurs' 1950 Examination records that the number of candidates was slightly fewer than in former years—823 compared with 885 in 1949. The percentage of passes was, however, 79.4 compared with 71. In addition to the candidates in this country there were 10 overseas entries against last year's 13, of which 7 and 5 passed, respectively.

Marconi's famous yacht *Elettra*, the floating laboratory on board which he conducted many of his important experiments, is to have a modern successor, *Elettra II*, recently purchased by the Marconi International Marine Communication Co. After Marconi's death, the *Elettra* was acquired by the Italian Government to serve as a wireless museum. *Elettra II*, a 72-foot twin-screw diesel yacht, will be fitted out as a floating laboratory to enable the development of marine radio and navigational aids to be carried out at sea.

"W.W." Diary.—Readers are reminded that copies of the *Wireless World* Diary for 1951 are obtainable from booksellers and stationers—to whom our publisher has distributed all available copies. In addition to the week-at-an-opening diary section it includes eighty pages of reference matter of the type frequently required but rarely readily available. The price of the Rexine edition is 3s. 8d. or in Morocco leather 5s. 6d.



THE NEW LOCATION of the Welsh television station at Wenvoe is indicated on this map on which is also shown the original site (dotted) at St. Nicholas and the existing broadcasting stations in the Bristol Channel area.

Welsh Television.—Local objections to the use of the site originally chosen at St. Nicholas, Glamorgan, for the Welsh television station has necessitated the acquisition of another. The P.M.G. stated in the House that negotiations were proceeding for the acquisition of a site on St. Lythan's Downs, near Wenvoe, Glam.

Ocean Weather Ships.—Changes in the call-signs of the British Ocean Weather Ships stationed in the North Atlantic are announced by the Ministry of Civil Aviation. The W/T call of station "I" is now 4YI instead of MEA and that of station "J" is 4YJ instead of MEB. The R/T calls have also been changed. They are now "Ocean Station Item" and "Ocean Station Jig." The m.f. non-directional beacon identification signs used by the ships have also been changed. They are now YI and YJ instead of QI and QJ. The frequency of beacon station "I" has been temporarily changed from 300 to 388 kc/s.

Electronics Exhibition.—The Second Exhibition of Industrial Electronics to be organized by the Midlands Branch of the Institution of Electronics will be held in Birmingham from 1st to 6th January. The second day of the exhibition will be set aside for a private trades preview for which free admission tickets are obtainable on request from the Chairman, Institution of Electronics, 31, Beech Road, Bournville, Birmingham, 30.

Suppression.—It is announced by British Transport that all petrol-engined vehicles regularly operated by the organization within the service areas of the present television stations are to be fitted with interference suppressors. The number of vehicles to be suppressed is sixteen thousand. Another contribution to the campaign for the suppression of interference is announced by City Motors of Oxford. All new and used cars and petrol-driven commercial vehicles supplied by them or their branches are being fitted with suppressors and will bear a label stating this.

Experiments on the confidential transmission by television of banking records are being carried out by Pye in collaboration with Glyn Mills & Co., the bankers, whose records office is situated some miles from the company's head office.

Measuring Interference.—The British Electrical and Allied Industries Research Association (E.R.A.) has issued a report entitled "The Measurement of the Time Constant of a Critically Damped Meter," by S. F. Pearce, which analyses the response of such a meter in equipment for measuring radio interference. The 8-page duplicated report is obtainable from the E.R.A., Thorncroft Manor, Dorking Road, Leatherhead, price 3s. 3d., including postage.

Tactile Training.—Among the exhibits used for the Exhibition for the Blind and Partially Sighted recently held at the Science Museum, South Kensington, was a five-foot cut-away model of a Mullard all-glass valve. By means of this model and descriptive labels in Braille the sightless were able to feel the disposition of the various electrodes.

"How the Brain Works."—During the recent television programme with this title, which was one of the Reith series of lectures, the Ediswan eight-channel electro-encephalograph was used to demonstrate the method by which electrical impulses from the brain can be measured and recorded.

E.I.B.A.—Among the prizes awarded at the recent Electrical Industries Ball at Grosvenor House in aid of the Electrical Industries Benevolent Association were a television receiver given by Ekco, two all-dry portables given by Cossor and a broadcast receiver given by Ferranti.

I.E.E. Students.—This year's chairman of the London Students' Section of the I.E.E. is T. J. Shelley, who is in the television transmission section of the B.B.C. Designs Department.

"Telefunken-Zeitung." the journal published by Telefunken Gesellschaft für drahtlose Telegraphie, Berlin, which ceased publication during the war, has reappeared. The first post-war issue is numbered 87/88.

Next Year's Ideal Home Exhibition, organized by the *Daily Mail*, will be held at Olympia, London, from March 8th to 31st.

Television Viewers.—A leaflet has been prepared by the British Television Viewers' Society setting out the objects of the Society which has developed from the Croydon and District Television Viewers' Society formed in 1947. A recent addition to the activi-

ties of the Society is the formation of a Technical Branch. Particulars of membership are obtainable from the Secretary, L. G. Pace, 146, Fairlands Avenue, Thornton Heath, Surrey.

BUSINESS NOTES

New Brimar Factories.—In an effort to increase the output of Brimar receiving valves and cathode-ray tubes, the Receiving Valve Division of Standard Telephones & Cables at Foots Cray, Kent, is opening a number of Feeder Plants, mainly in country districts, in the county. The main purpose of these Feeder Plants is to take advantage of relatively small groups of suitable labour in country districts. The exception is at Rochester where a fairly large area of a former aircraft engine factory at Rochester Airport has been acquired.

Pye inform us that the decision of the Swedish Air Force to use a.m. equipment instead of f.m. for its ground and air radio services was considerably influenced by the demonstration of Pye mobile and fixed equipment working on a frequency of about 100 Mc/s. A range of some 33 miles was attained between the 15-watt fixed station and the 5-watt mobile. Similar equipment has been ordered by the Luxembourg authorities for use on fire tenders at the airport.

Turkish S.W. Station.—A new 100-kW short-wave broadcasting station at Elmesgut, about 10 miles from Ankara, was opened by the Turkish Broadcasting Administration at the beginning of the month. The transmitter, aerial system—consisting of five 250-foot masts supporting the arrays—and some ancillary equipment were provided by Marconi's. The company also supplied an Outside Broadcasting unit incorporating a short-wave radio link.

C.R.T. Testing.—A new service depot for testing Ediswan cathode-ray tubes has been opened by the Edison Swan Electric Co., at Perfecta Works, Henstead Street, Bromsgrove Street, Birmingham, 5 (Tel: Midland 6425).

Belling-Lee.—In the review of television accessories at the radio exhibition in our October issue it was inadvertently stated that Belling and Lee used a folded dipole in their multi-element aerial systems. This firm has always favoured the plain dipole, even for fringe-area arrays, and they fit a quarter-wave transformer to match the aerial to the feeder.

United Nations Headquarters at Lake Success, New York, is calling for tenders by December 27th for equipment for a sound-reinforcing system. Among the apparatus required are 1,500 table and chair loudspeakers, a number of horn-type and cone reproducers and associated transformers. Particulars are available from the Commercial Relations & Exports Department (Industries Branch) Board of Trade, Room 1080, Thames House North, Millbank, S.W.1. Reference CRE (IB) 70985/50.

G.E.C. announce that their communications receiver BRT 400 is used by all the Swedish armed forces and the Post and Telegraphs Department.

Market Investigation.—Whilst visiting the Rhodesias and South Africa between March and September next year the managing director of W. J. Groom & Co., of 22, Fenchurch Street, London, E.C.3, offers to investigate and report on the question of representation for British manufacturers in those countries.

J. H. Brierley, Ltd., the well-known manufacturers of sound recording and reproducing equipment, are moving on January 1st from 46, Tithebarn Street, Liverpool, to new factory premises on the Kirby Trading Estate, Liverpool.

Robshaw Brothers, Ltd., of 232-4, High Street, Rochester, Kent, have been appointed the sole distributors in the United Kingdom to the wholesale and retail trade of Igranic jacks, plugs, rheostats and potentiometers.

MEETINGS

Institution of Electrical Engineers

Radio Section.—"The Use of Saturable Reactors as Discharge Devices for Pulse Generators," by W. S. Melville, B.Sc. (Eng.), at 5.30 on January 10th at Savoy Place, London, W.C.2.

North-Eastern Radio Group.—"The Operation and Maintenance of Television Outside-Broadcast Equipment," by T. H. Bridgewater at 6.15 on January 15th at King's College, Newcastle-on-Tyne.

Northern Ireland Centre.—"Fifty Years' Development in Telephone and Telegraph Transmission in Relation to the Work of Oliver Heaviside," by W. G. Radley, C.B.E., Ph.D. (Eng.), at 6.45 on January 9th at Queen's University, Belfast.

Western Centre.—"Oliver Heaviside," by Professor G. H. Rawcliffe, M.A., D.Sc., at 6.0 on January 8th at the Technical College, Bath.

British Institution of Radio Engineers

London Section.—A Symposium on Hearing Aids—"Deafness; its Clinical Aspects, and the Possibilities of its Alleviation Medically and by Deaf Aids" by E. R. Garnett Passe, F.R.C.S.; "A Master Hearing Aid" by E. Aspinall, B.Sc.; and "The Design of Commercial Hearing Aids" by J. P. Ashton, B.Sc. (Eng.), at 6.30 on January 10th at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, W.C.1.

North Eastern Section.—"Stages in the Development of a Small High-Frequency Oscillograph" by H. A. Dell, B.Sc., Ph.D., at 6.0 on January 10th at Neville Hall, Westgate Road, Newcastle-on-Tyne.

North Western Section.—"Marine Radar" by G. W. L. Davis at 6.45 on January 4th at the College of Technology, Manchester.

Scottish Section.—"Frequency Modulation and F.M. Measuring Equipment" by E. D. Hart, M.A., and A. G. Wray, M.A., at 6.45 on January 11th at the Institution of Engineers and Shipbuilders, Glasgow.

South Midlands Section.—"Ultrasonic Generators for High Powers" by B. E. Nottingh, Ph.D., at 7.0 on January 17th at the Exhibition Gallery, Public Library, Rugby.

GOVERNMENT RESEARCH

Published Reports on the Work of the N.P.L. & D.S.I.R.

A REPORT of the work carried out at the National Physical Laboratory during 1949 is now obtainable from H.M. Stationery Office. It covers the activities of the ten Divisions of the Laboratory and that of the Electronics Section which, until 1948, was attached to the Radio Division. The recently published report of the Department of Scientific and Industrial Research for 1948/49 also devotes a few pages to radio research.

During the year preliminary work for the inauguration of regular transmissions of standard radio frequencies was undertaken, the Electricity Division accepting responsibility for the actual standard of frequency and the G.P.O. for the transmissions which are made from Rugby. Other activities of this division included work on dielectrics at the extra high frequencies and examination of polytetrafluoroethylene (P.T.F.E.) as a dielectric in radio-frequency cables.

Among the subjects investigated by the Radio Division is the measurement of radio noise of all kinds and improvement in the technique of locating thunderstorms and atmospheric disturbances by radio direction finding.

Curiously enough, more precise knowledge of the propagation characteristics of the really long waves (12,000 to 20,000 metres) was found necessary during the development of new marine and aeronautical navigational aids. It has so far been revealed that for frequencies of about 16 to 20 kc/s the effective reflecting region in the ionosphere appears to be about 70 km during daytime and 85 to 90 km at night.

Ionospheric observatories are maintained and operated by the Radio Division at Radio Research Station, Slough; Fraserburgh, Scotland; the Falkland Islands and Singapore. Hourly measurements are made of the height, critical frequency and absorption factor of the ionosphere. These observations are correlated with those made by other authorities throughout the world.

The N.P.L. Report costs 1s 9d and the D.S.I.R. Report 5s 6d.

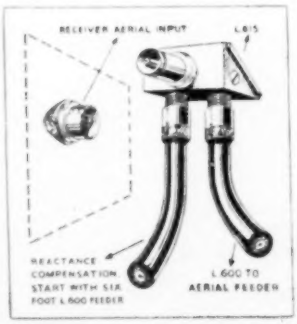
THE "BELLING-LEE" PAGE

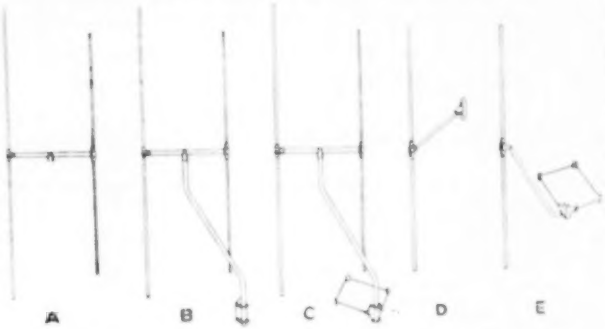
Providing technical information, service and advice in relation to our products and the suppression of electrical interference

That last ounce

Here is a suggestion for those who are situated in truly fringe areas, for those who have done everything they know (such as using semi-air-spaced feeder) to get a better picture, and who are prepared to gamble a few shillings to try any reasonable dodge to improve it. If the picture is already good, the improvement likely to result from this dodge will not be worthwhile, but if the picture is only just there, then this trick may make all the difference. It may be applied to any aerial and it is immaterial whether the feeder is co-axial or balanced. We will assume that co-axial is in use. First buy an L.615*1 twin right angle co-axial plug to fit the co-axial aerial inlet socket on the back of your receiver and six feet of L.600 *2 co-axial feeder. Load the short length of feeder into one side of the newly purchased twin plug. With the aerial plugged normally into the receiver, tune till you obtain the best possible result, withdraw the aerial plug, load the aerial feeder into the vacant position in the twin plug, and plug into the receiver. Now do not worry if the picture is worse or even non-existent. With a pair of cutters, reduce the length of the six-feet of feeder an inch at a time (taking care not to permanently short-circuit core to screen in the process), closely watching the picture quality all the while.

The picture may get worse, and may get better again; be careful as the picture reaches the original quality as the length is very critical. In a few cases it may not be possible to obtain any improvement, in which case your monetary outlay will have been in vain, but with a total outlay of something over £55, surely it is worthwhile spending 6/6 on a probable worthwhile improvement.





A word of caution

Although the conventional self-supporting dipole *3 has become the recognised method of collecting the television signal energy, there are other types of aerials which can be used. In this category we can mention Rhombics, Half Rhombics, Tilted Wire, Beverage and Sterba, as a few variants of the "long wire" aerial working on the phase addition principle.

A keen experimenter or dealer can usually make up one of these types of aerial by "cut and try" methods. Sometimes polarisation effects and reflections *peculiar only* to the site will result in an aerial which, although an eyesore, may provide better gain and signal-to-noise ratio than a relatively expensive self-supporting aerial of the conventional type.

An enterprising dealer, who may be faced with loss of sales of television sets because of the additional expense of the aerial, may attempt to secure the sale even for a lower profit, if his staff are sufficiently technically minded to experiment with these other forms of collectors, but, the danger in this is the harm which may be done to the Industry while the present attitude of local authorities to television aerials in general is maintained. For an outdoor aerial, the conventional types are undoubtedly less of an eyesore then many long wire types and the avoidance of the latter is a good point in favour of the Industry if it has subsequently to thrash the matter out with the local authorities. Finally, there is the danger that an aerial of this type, which is really designed around the special circumstances prevailing at a particular site, may be packed and distributed over the counter without careful tests over a wide range of locations in which it may be wholly unsuited.

Car Ignition Suppression

Since the B.B.C. have been showing their excellent film describing and demonstrating the cure of this form of interference we have heard that some dealers apparently still have showcards showing the price of our L.630 suppressor as being 2/-. The price was reduced to 1/6d. nearly eighteen months ago. Price labels for old cards already in existence are available on request. It is most encouraging to realise that some real interest is now being shown in this matter.

* 1 L615 Twin right angle co-axial plug ..	4	0
* 2 L600 ⅜in. diameter co-axial cable per yard	1	3

*** 3 Prices of aerials illustrated**

The first suffix of list numbers below indicates the channel on which the aerial will operate (i.e. /1 = London; /4 = Midland.)

A L802/1 or 4/C Junior "H" with mastcap..	£2	10	0
B L802/1 or 4/W Junior "H." with cranked mast and wall bracket	£3	15	0
C L802/1 or 4/L Junior "H" with cranked mast lashing and bracket	£4	7	6
D L803/1 or 4/W Simple dipole with support arm and wall bracket	£1	17	6
E L803/1 or 4/L Simple dipole with cranked arm and lashings....	£3	0	0

BELLING & LEE LTD
CAMBRIDGE ARTERIAL RD., ENFIELD, MIDDX., ENGLAND

AN AMAZING NEW AMPLIFIER

FACTUAL FIGURES from A–Z

FROM PICK-UP TO SPEAKER, *INCLUDING* TONE CONTROL CIRCUITS

Not merely a laboratory measurement of an amplifier only, but the whole story of the "A-Z" as it will perform under users' conditions

National Physical Laboratory Report on Tests of Amplifier

(Marked : Type A-Z, Serial No. A50/1, Sound Sales)

Tested for : SOUND SALES LTD., WEST STREET, FARNHAM, SURREY. *Reference* : LETTER, RNW/DES/AZ. *Dated* 31.8.50.

The instrument was tested for sensitivity at various frequencies between 20 and 25,000 cycles per second. The total harmonic distortion was measured at 60 c/s and 1,000 c/s ; the hum and noise output voltage and the output impedance were also determined.

The supply to the instrument was at 230 volts and 50 c/s ; the connection to earth was independent of the mains supply and made directly to the instrument.

The input was in all cases made to the lead provided, with the controls set as follows : L.F. cut, 0 ; volume 12 (maximum) ; bass, 0 ; treble, 0. A load resistance of 15.0 ohms was connected to the output of the amplifier by means of the leads provided.

SENSITIVITY

The input required to develop an output of 12 watts in the load at 1,000 c/s was 0.125 ± 0.002 volt.

The input required to develop an output of 8 watts was measured at several frequencies ; the results obtained are given in Table I below :

TABLE I

8 WATTS OUTPUT

Frequency, c/s	Input, volt
20	0.100
60	0.101
1,000	0.102
3,000	0.102
5,000	0.102
10,000	0.102
15,000	0.102
20,000	0.102
25,000	0.102

HARMONIC DISTORTION

The harmonic distortion was measured with an output of 12 watts at 60 c/s and 1,000 c/s. The second and third harmonics of the fundamental, in about equal proportions, were found to predominate. The total harmonic voltage expressed as a fraction of the fundamental is given in Table II below :

TABLE II

12 WATTS OUTPUT

Input Frequency	Ratio, Total Harmonics / Fundamental
60 c/s	0.002
1,000 c/s	0.002

HUM AND NOISE

The hum and noise output voltage was measured with the input lead short circuited and found to be 0.005 volt.

OUTPUT RESISTANCE

The output resistance was measured at a frequency of 1,000 c/s for output powers of 3 watts and 12 watts in a load resistance of 15.0 ohms.

The results obtained are given in Table III below :

TABLE III

Power Output, watts	Output resistance, ohm
3	0.50 ± 0.05
12	1.2 ± 0.1

Date 5th October, 1950.
Reference E.488.18.
Passed by L.M.F., C.H.R.

E. C. BULLARD, *Director.*
L. HARTSHORN,
for Superintendent, Electricity Division.

You are welcome to a demonstration of this amazing new amplifier, which costs £30 complete, at our London Office and Showrooms

SOUND SALES LIMITED, Lloyds Bank Chambers, 125 Oxford Street, London, W.1
(Tel. GERrard 8782)

WORKS: West Street, Farnham, Surrey (Tel. Farnham 6461)

Colour Television

Frequency-Interlace System

By A. DINSDALE

IN the United States the subject of colour television has been under heated discussion for some time, and the Federal Communications Commission has been holding hearings and viewing demonstrations of rival systems developed by Columbia Broadcasting System, Radio Corporation of America, and Color Television, Inc. The main issues have been which system to adopt, and which frequency bands to assign to colour. While discussion rages, some 7,000,000 black-and-white sets have been sold, and manufacturers are turning out more at the rate of half a million a month.

Recently, the F.C.C. announced that it was prepared to recommend the C.B.S. system even though this system uses a mechanically driven colour disc, and cannot be received on existing black-and-white receivers. In making this "threat" the F.C.C. blasted receiver manufacturers for not making their black-and-white sets so that they could be used to receive C.B.S. colour transmissions in black-and-white, and gave the manufacturers thirty days to make up their minds what they wanted to do. If manufacturers complied, the F.C.C. promised to reopen the entire discussion and consider other systems which might become available, and which promised to provide receivers easily interchangeable from colour to black-and-white. If the manufacturers will not agree to modify their present sets, then the F.C.C. threatens to issue an immediate order adopting the C.B.S. system.

Meanwhile, the General Electric Company, at the eleventh hour, announced a new system of its own, a system worked up by R. B. Dome, an engineer in G.E.'s Electronics Park plant at Syracuse, N.Y. Although still in the strictly theoretical stage, G.E. took the extraordinary step of announcing it to try and get under the wire of any F.C.C. decision. If, in spite of everything, the F.C.C. adopts the C.B.S. system, this new, proposed G.E. system may never be developed to the point of practical application.

The description of the new proposed frequency-interlace system given in this article is based on data supplied to the F.C.C. by the General Electric Company.

IF the bandwidth available for television signals were to be arbitrarily divided into three equal parts, one for each message (or colour), the rate of transmission of the entire information would have to be slowed down to one-third that used in monochrome. This could be done, of course, but the flicker problem would be a serious limiting factor to commercial acceptance. A way of transmitting the three message simultaneously in the same frequency spectrum, by the use of frequency multiplexing, or "frequency interlace," is therefore desirable.

As the term frequency interlace implies, the frequencies employed by the three messages are sandwiched so as to be non-interfering. This can be done in scanned information systems like television because it has been found that the video frequencies associated with a television signal are bunched around harmonics of the line frequency, and that a large part of the available spectrum is unused. It has been estimated that about 46 per cent of the space between harmonics is not occupied.*

Suppose the video-frequency bandwidth available is 4 Mc/s. Furthermore, let it be assumed that scanning frequencies compatible with monochrome television are to be used, namely, a vertical or frame frequency of 60 c/s, and a line rate of 15,750 c/s. This results in the U.S. standard 525-line system employing two-fold interlace. Suppose that the three primary colours elected to be used in the system are green, red and blue.

At the camera the composite television picture being televised is split by electro-optical means into three separate groups of signals associated with the three primary colours. Each channel may contain frequencies extending up to 4 Mc/s. The signals associated with the colour green may be regarded as the basic signals, and may be used to modulate the picture carrier in the same manner as in a monochrome transmitter.

Since the line frequency is 15,750 c/s, it will be found that the sideband energy is chiefly bunched at frequencies spaced from the carrier by 15,750 c/s, 31,500 c/s, 47,250 c/s, etc., out to 4 Mc/s. It is planned to use the spaces between these harmonics to transmit the information associated with the two remaining colours.

The video frequencies associated with a second colour (e.g., red) may be utilized as modulating frequencies for a video-frequency subcarrier. This subcarrier frequency is carefully selected to lie exactly midway between two harmonics of the line frequency, or in other words, at an odd multiple of half the line frequency. Half of 15,750 c/s is 7,875 c/s, so that a frequency of 3,583,125 c/s, which is the 455th multiple of 7,875 c/s, may be selected. Now this subcarrier is modulated with video signals of the red channel, and the modulated wave is superimposed on the green channel signals. It is evident, then, that the red video signals will lie halfway between green signal line-frequency harmonics, in unused parts of the spectrum.

The entire red spectrum is not used as modulating frequencies, since a number of investigators have found that acceptable colour reproduction may be obtained by identifying only the lower video frequencies with their respective colours. The higher video frequencies may be transmitted either by green alone or by the principle of mixed highs. Good reproduction will be obtained if red is transmitted as red out to only 1 Mc/s. Furthermore, use may be made of vestigial-sideband transmission of the red signal, so that the lower sideband is the dominant one. The spectrum of the combined green and red signals may therefore be as shown in Fig. 1.

* "A Theory of Scanning and its Relation to the Characteristics of the Transmitted Signal in Telephotography and Television," Pierre Mertz and Frank Gray, *Bell System Technical Journal*, Vol. 13, No. 3 (July 1934), pp. 464-516.

Fig. 1. Spectrum of green and red video frequencies as radiated.

Fig. 2. Spectrum of green and red video frequencies at detector output.

This signal may be received by a conventional monochrome receiver insofar as the r.f., i.f., and second detector are concerned. The video frequency spectrum out of the detector would then be as shown in Fig. 2. A more detailed view of the frequency spectrum in the vicinity of the red sub-carrier is shown in Fig. 3.

Colour Signal Separation

The way in which the signals associated with the two colours are interleaved is now clearly revealed. It is necessary now to provide some means at the receiver for separating the signals for portrayal on the picture tube of the correct colour. One way of accomplishing this would be to employ an elaborate wave filter having multiple pass bands for the desired frequencies, and multiple elimination bands to exclude the undesired frequencies. Such a filter would probably be too expensive for home receivers because of the large number of sections indicated.

Fortunately, a cheap natural filter is available in the form of the human eye. The satisfactory operation of the system depends to a considerable extent on the physiological phenomenon known as persistence of vision. It will be observed that any one line of the green television picture will be modulated in intensity at the rate of the red sub-carrier, but that two frames later in time, namely, in 1/30th of a second, the modulation effect will be 180° out of phase with the modulation of the first frame. Thus, a lighter "dot" on field No. 1 will appear as a darker "dot" on frame No. 3, and *vice versa*, so that in the eye the mean illumination tends to average out to a medium background.

This principle is illustrated in Fig. 4, in which are depicted light intensities along a single green line in frame No. 1 and in frame No. 3. The sine wave is the red sub-carrier simultaneously present, and is shown here to be amplitude-modulated by low-frequency red picture signals. If the eye were a perfect long-time integrator the visual sensation would be given by the line marked "mean intensity" which corresponds in this case to the desired green signal. The repetition rates involved here are not fast enough to give perfect integration, but the practical result is believed to be sufficiently close to the ideal to be commercially acceptable.

Moreover, the superposition of frames yields twice the number of dots per line as one frame alone gives, so that a very fine dot structure results. Its fineness is comparable to horizontal scanning line structure and disappears at substantially the same distance away from the picture tube that normal line structure disappears. Thus, although both the red and green signals appear on the green gun, the red is effectively filtered out by the eye and only the green remains.

The information contained in the red camera signal

Fig. 3. Detail of frequency band in vicinity of the red subcarrier.

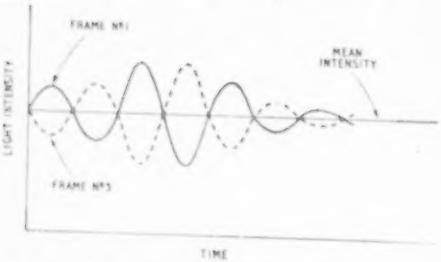
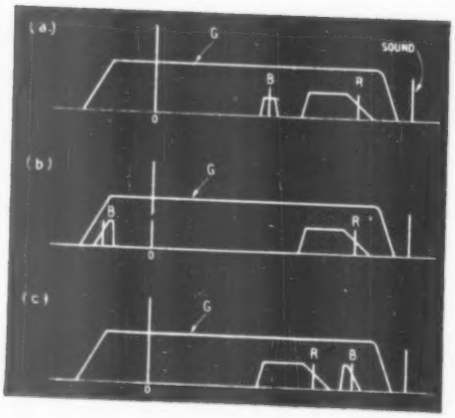


Fig. 4. Light intensity along the same line on alternate odd frames.

Fig. 5. Alternative possibilities for the location of the blue subcarrier.



above 1 Mc/s and up to 4 Mc/s may be superimposed on the green signal to yield a mixed-high signal above 1 Mc/s.

The video frequencies associated with the third colour, blue, may be transmitted as modulation on a second sub-carrier. Again, as in the case of the red signals, only the lower blue frequencies need be transmitted, so that a comparatively narrow channel should suffice. A blue video band up to 0.2 Mc/s may be sufficient. Fig. 5 shows several alternate possible locations for the blue sub-carrier. It is not yet known which of these various methods is likely to provide the best all-round performance. Consider, for example, the third alternative in which the red sub-carrier is shown moved down to about 3.2 Mc/s, or to 3.189375 Mc/s, the 405th multiple of 7,875 c/s, while the blue carrier may be located just under 4 Mc/s at 3.898125 Mc/s, the 495th multiple of 7,875 c/s. (The 3.189375 Mc/s signal may be derived from the 3.898125 Mc/s signal by dividing the latter by 11 and then multiplying the quotient by 9.)

Again, as was the case with red and green, the blue signal appearing on the green gun is effectively filtered out by the eye, as are the green signals appearing on the red and blue guns. The blue and red signals, since they do not overlap in frequency, do not exhibit this effect.

As stated before, the high video frequencies may be represented by the green channel alone. In order to avoid a greenish tinge to high frequencies the green highs may be taken off the green video channel by the shunt connection of a suitable high-pass filter and added to the blue and red guns (as well as direct connection to the green gun) of the reproducing means to produce black-and-white fine detail. Alternatively, blue and red highs may be added to the green channel at the transmitter and taken off from the green video channel in the receiver to feed the blue and red guns as well as the green gun. The cut-off frequency of the high-pass filter would be selected at approximately the cut-off frequency of the red-channel low-pass filter, or in the example given, at about 1 Mc/s.

A schematic of the colour section of a simple receiver for the reception of a television transmission of the form of Fig. 5 (c) is shown in Fig. 6. The i.f. is kept wideband at the anode of the last i.f. amplifier purposely, so that the blue channel will not be adversely attenuated before it is detected in the blue detector.

Following this detector is an amplifier and tuned circuits centred around the blue subcarrier to remove effects of the sound carrier and the red subcarrier. The blue detector yields the blue low-frequency video signals which are amplified and fed to the blue gun grid.

Appropriate sound traps (and if desired lane sub-carrier traps) are employed before the green and mixed-highs detector. The output of this detector is amplified and fed to the green gun. Two shunt circuits leading from the anode of the green-channel amplifier feed respectively the red detector through a 3.2-Mc/s band-pass circuit and the mixed-high filter for the addition of mixed highs into the red and blue guns. The 3.2 Mc/s filter feeds a red signal detector and the output of the detector feeds a red amplifier connected to the red gun.

Inter-colour Cross-talk

The receiver as shown here employs six sets of valve elements over and above those a receiver would employ if designed to receive black-and-white pictures. By using available combination type valves, the actual number of valves may be as low as three. The polarity of the detectors may be reversed from

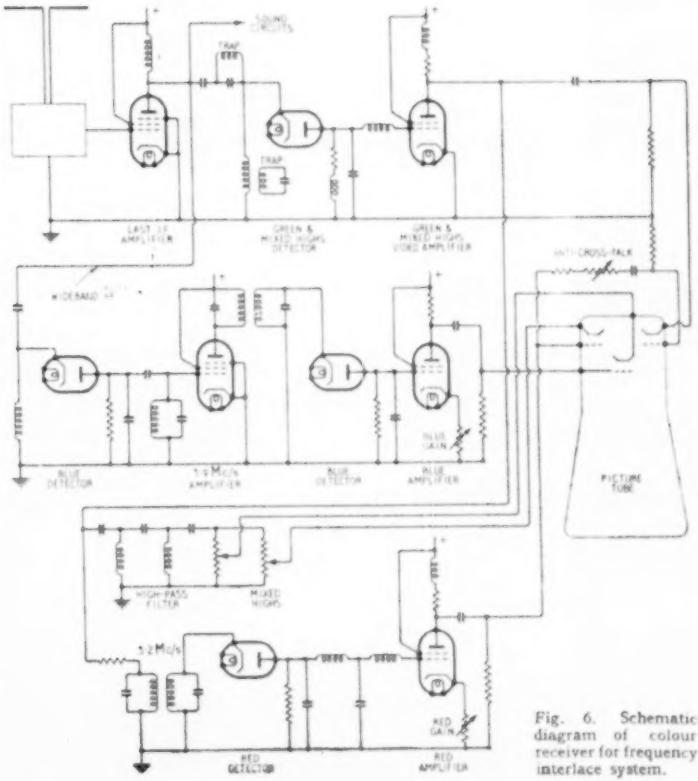


Fig. 6. Schematic diagram of colour receiver for frequency interlace system.

those shown to produce the right phase of light intensity; i.e., a positive picture. Alternatively, the picture tube gun connections may be reversed to achieve the same result.

A mathematical analysis of the action of the green detector shows that some of the red low video frequency modulation will appear as low frequency in the detector output because the system is single sideband. The presence of this low-frequency spurious signal in the green channel may cause an undesirable cross-talk effect making itself evident in a change in hue but not in geometrical design. This colour shift cross-talk effect may be reduced to a small amount if desired by feeding some low-frequency red signals into the green gun in phase reversal to the cross-talk. Again depending upon the modulation polarity of the red signals, the anti-cross-talk connection may be made either to the cathode or to the grid of the green gun as required. It is shown here connected to the grid of the green gun.

The simpler receiver shown in Fig. 6, while it contains sufficient circuit elements to receive colour pictures, has for simplification purposely omitted two factors which may be desirable in a commercial product. These are d.c. restorers and a.g.c. The green a.g.c. and the green restorer are the same as for black-and-white receivers and need not be discussed in detail. The red and blue d.c. restorers are likewise conventional.

A.g.c. for the red and blue channels will probably be needed in a practical receiver to take care of receiver i.f. response variations due to tuning and effects of a.g.c. on the i.f. response shape.

Many methods of transmitting reference signals for use by the a.g.c. systems will suggest themselves, but one of the simplest methods is that adopted by communication services which employ suppressed carrier channels. This method is to transmit a pilot signal of fixed amplitude, which may be continuous except for blanking intervals, but which lies outside the normal communication channel frequencies. Thus, in the red channel, a continuous unmodulated wave at a frequency of 1.1 Mc/s from the red carrier might be used as a pilot frequency.

Another pilot frequency 220 kc/s from the blue channel carrier could be used for blue a.g.c. In a practical receiver, however, it is quite likely that the red and blue signals would maintain their relative

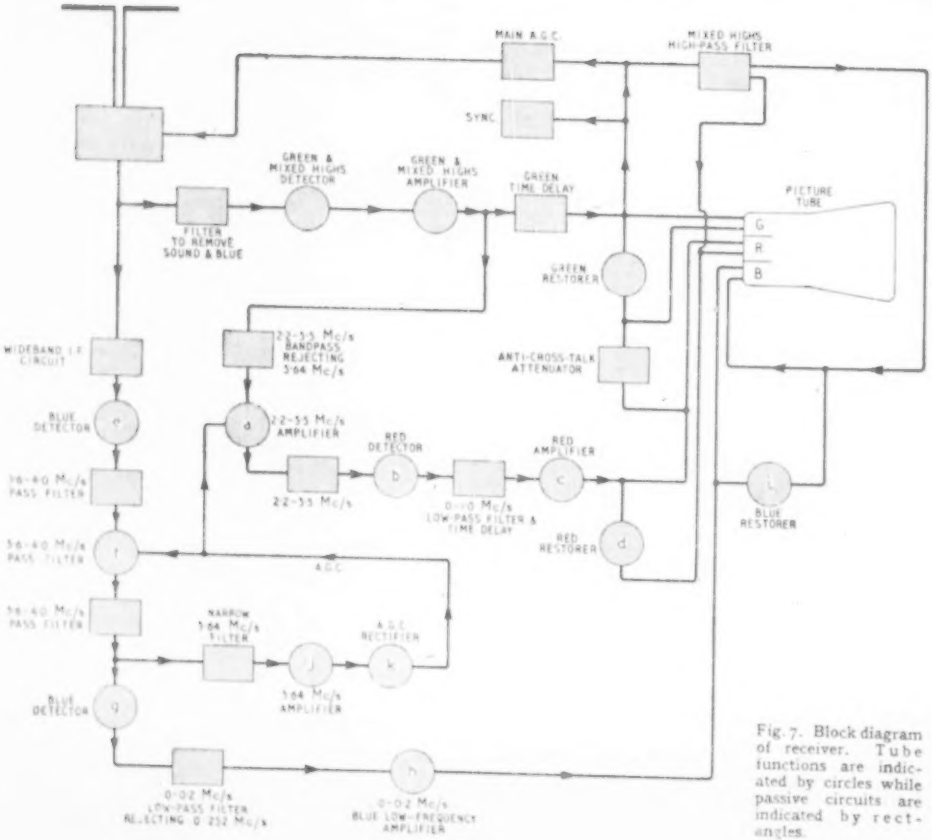


Fig. 7. Block diagram of receiver. Tube functions are indicated by circles while passive circuits are indicated by rectangles.

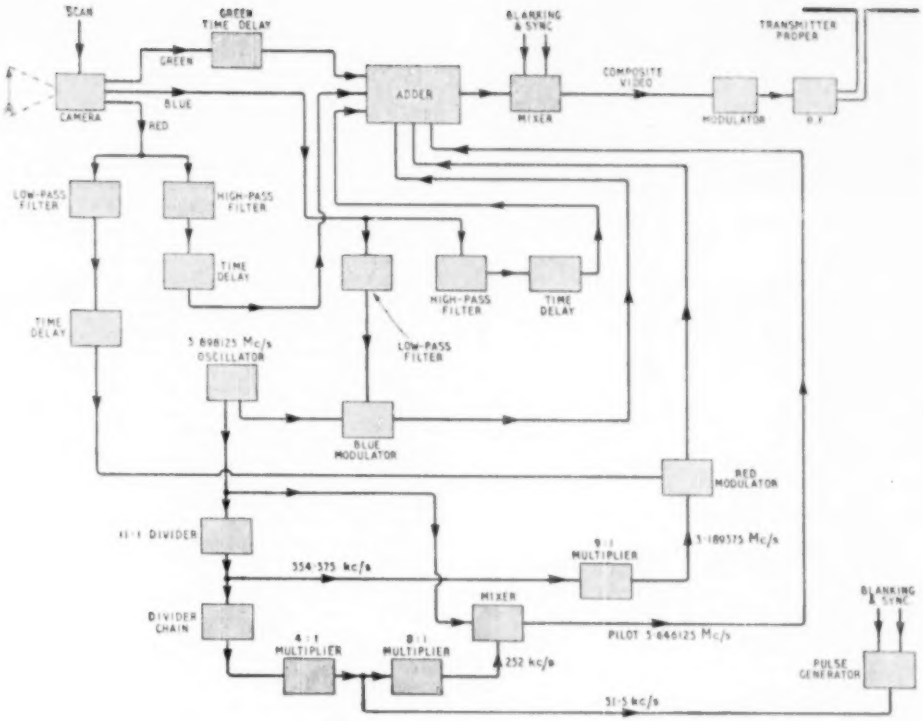


Fig. 8. Transmitter block diagram.

magnitudes fairly well, but that the green might change with respect to them depending upon the position of the green carrier along the slope of the i.f. response characteristic. Therefore, a single a.g.c. for the red and blue channels may prove to be adequate, in which case a pilot frequency may be radiated in the vicinity of 3.65 Mc/s in the guard band between the blue and red channels shown in Fig. 5(c).

The exact frequency for the pilot may be 3.646125 Mc/s, the 463rd harmonic of 7,875 c/s. This frequency may be generated by subtracting the eighth harmonic of 31,500 c/s from 3.898125 Mc/s. This pilot would then lie 252 kc/s below the blue carrier, or 456.75 kc/s above the red carrier in a position so that the pilot carrier can be eliminated from the blue and red low-frequency signals by the use of suitable traps, and so that its effect on the green picture will be cancelled by the eye.

The pilot a.g.c. signal may be amplified and rectified to obtain a.g.c.-d.c. control voltage which may be applied to the 3.9 Mc/s blue signal amplifier as control grid bias. The d.c. may also be applied to an amplifier which may be inserted in the system shown in Fig. 6 just prior to the red detector. D.c. delay voltage may be employed on the a.g.c. rectifier to make the output become quite uniform regardless of variations in output over a suitably wide range in magnitudes. Actually, of course, since the receiver as a whole has its gain controlled by the green channel, it is not likely that very extreme ranges in input variations to the red and blue channels would occur.

The d.c. delay voltage may be made adjustable if desired so that the service man at the time the receiver is installed may adjust this control (as well as the individual red and blue gain controls) for best colour balance.

Time-delay networks may be required in the green and red channels to give a resultant overall uniform time-delay equal to the time-delay of the blue low-frequency channel, because the blue channel is the narrowest and therefore will probably have the greatest inherent time-delay.

A block diagram of the colour portion of a receiver incorporating some of the finer points mentioned in the above discussion is shown in Fig. 7. This receiver employs the following valve functions above what is required for a black-and-white receiver:

(a) One 2.2-3.5 Mc/s Red i.f. amplifier.
(b) One Red diode detector.
(c) One 0-1 Mc/s Red video amplifier.
(d) One Red restorer diode.
(e) One Blue diode detector.
(f) One 3.6-4.0 Mc/s Blue i.f. amplifier.
(g) One Blue diode detector.
(h) One 0-0.2 Mc/s Blue video amplifier.
(i) One Blue restorer.

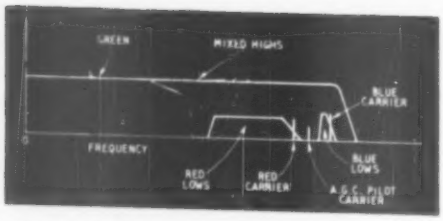


Fig. 9. Spectrum at output terminals of transmitter adder

(j) One 3.64 Mc/s a.g.c. carrier amplifier.
(k) One a.g.c. rectifier diode.

These eleven valve functions can, of course, be obtained by employing fewer than eleven separate valves when use is made of double-purpose valves.

The picture tubes which may be employed as an electro-optical transducer in the receiver may be any of the forms described in the literature including:

(a) Three separate tubes, one for green, one for red, one for blue.
(b) A three-gun single tube as demonstrated by R.C.A.
(c) A single-gun single tube as demonstrated by R.C.A.

The first two forms of the transducer, (a) and (b), require no additional apparatus, but the third form would require a circular sweep generator and an auto-sampler, the total number of added valves possibly being as high as six. For this reason, and for reasons of avoiding the problems attendant to optical registration, form (b) would appear to be the preferred form for the transducer.

The transmitter for the frequency-interlace colour system would be a standard transmitter with some modifications. A block diagram is shown in Fig. 8. An adder having six input terminals is shown in this diagram into which may be fed:

1. Green video signals.
2. Red lows on a subcarrier.
3. Red highs direct.
4. Blue lows on a second subcarrier.
5. Blue highs direct.
6. A.G.C. pilot signal.

The adder output frequency spectrum would then look like that shown in Fig. 9.

Time-delay networks may also be required in the transmitter, and, if so, would probably go into the green and red channels, since once again the blue channel will be retarded the longest inherently because of the relatively narrow bandwidth devoted to blue low-frequency components. Time-delay networks may also be required in the red high and blue high circuits as indicated in Fig. 8.

The video signal is capable of being transmitted over cable and radio-relay networks without loss of fidelity providing the characteristics of the network are such as to provide good transmission up to 4 Mc/s. If the cable or radio link has a pass band of only 2.8 Mc/s, the picture is still usable as a black-and-white picture, but not as a colour picture because the blue and red information would be missing or incomplete.

Anomalous transmission vagaries at u.h.f. are rare and hence it is not anticipated that any difficulties will be encountered which would temporarily blot out a portion of the radiated band, thereby removing a blue or a red carrier and their sidebands. Instead, it is to be expected that a continuous flow of all of the information would be received.

This colour system is compatible in that present black-and-white receivers, regardless of video bandwidth, may be used to receive colour transmissions in black-and-white. The green picture would constitute the signal employed in reception. Cross-talk would cause no trouble because it is geometrically in the same position on the screen as the green signal itself. If the polarity of modulation is chosen carefully, the black-and-white tube may actually be aided by the cross-talk to give lights and shadows even when the green component is weak.

When the colour receiver is tuned to a black-and-white transmission, all of the guns may be fed from the main signal. The operator of the receiver may do this manually in low-priced receivers. Switching would be indicated because the red and blue channels would be dead and the picture would be green. On the other hand, if the receiver were switched for standard black-and-white reception, and a colour signal were tuned in, the operator would have no positive signal that the transmission was in colour and would have to "try" the colour switch to see if it were in colour. On a more expensive receiver, the switching could be accomplished automatically. For example, if the pilot signal at 3.64 Mc/s is employed its presence in colour transmissions could be used to operate a relay to do the colour switching. An absence of 3.64 Mc/s would fail to close the relay so that the receiver would automatically be set up for black-and-white reproduction.

As yet this system has not been completely set up and demonstrated. However, preliminary laboratory tests have been made to verify some of the basic principles.

For example, a continuous-wave oscillation frequency representative of a red carrier has been superimposed on a black-and-white picture and it has been determined that the best frequencies for it are any of those lying between line frequency harmonics. When the injected frequency coincides with a line frequency harmonic, vertical black-and-white bars are visually evident. When the frequency of the injected wave is shifted to lie midway between harmonics of the line frequency, two effects are noticed:

(1) A dot pattern replaces the vertical line pattern.
(2) The variations of light intensity are reduced.

These points substantiate the theory.

Secondly, low-frequency amplitude modulation has been applied to the injected carrier and low-frequency cross-talk observed; but the low frequencies at the output of a detector, tuned to the injected frequency, when inserted into the video channel in the proper corrective phase, substantially removed all traces of low-frequency cross-talk. This experiment therefore verified the anti-cross-talk possibilities referred to in the description of the system.

When the injected carrier frequency is above 3 Mc/s the fine dot pattern has about the same quality as normal line structure and disappears at about the same viewing distance from the picture tube. No observable "twinkle," "flicker," or "crawling" could be obtained in any of the tests, indicating freedom from these particular types of disturbance.

The proposed frequency-interlace colour television system appears to offer the following advantages over other known systems:—

1. All precision equipment is localized at the

transmitter, so that the receiver can be relatively low in cost, reliable in operation, easy to adjust and maintain, and simple in construction. It is estimated that only six more valves are required than in a monochrome receiver.

2. The receiver should be free from colour shifts due to noise interference.

3. The system is inherently compatible with present (American) monochrome standards.

4. The receiver should exhibit a complete absence of twinkle, crawl, or flicker and of field-sequential colour fringing.

The anticipated disadvantages of the system are:—

1. The requirement of either (a) more accurate receiver alignment and tuning, or (b) an effective automatic gain control on each colour.

2. Possible colour fringing due to differential time-delay in propagation between colour carrier frequencies. (This is not expected, but tests ultimately should be made to check it.)

3. Full 4 Mc/s bandwidth is required in relaying.

4. Possible second-order colour fringing due to incomplete "physiological filtering" in rapidly moving objects.

NEW BOOK

The Theory and Design of Inductance Coils. By V. G. Welsby, Ph.D., A.M.I.E.E. Pp. 180; 61 diagrams and photographs. Macdonald & Co. (Publishers), Ltd., 43, Ludgate Hill, London, E.C.4. Price 18s.

ANY radio engineer worthy of the name can design an air-cored tuning coil or an iron-cored smoothing choke with confidence that a sample made up to his instructions will turn out to have an inductance reasonably close to specification. His expectations regarding its a.c. resistance or Q may be rather vaguer, however. When it comes to designing a dust-cored coil to a specified Q (as well as inductance), and to a specified harmonic distortion limit, very many will have to admit the necessity of falling back on trial-and-error, aided by such experience as they possess. The pre-calculation of losses, especially in high-frequency iron-cored coils, and clear knowledge of how they are related to dimensions and frequency, is not a widely distributed ability. There is, therefore, ample need for this new book, by a specialist on the subject at the G.P.O. Research Station. It covers the design of the many types of inductors used in communications, and is applicable to others, such a fluorescent lighting chokes.

One source of difficulty is the large number of variables, both physical and electrical. Another is the non-linearity of ferromagnetic materials. The author has gone far towards reducing such matters to routine design, and has devised graphical methods to minimize labour; but it must not be supposed that one can skip the theory and employ a few, cut-and-dried results. Many of the results are valid only within certain limits, and must be used intelligently. Some of them admittedly can give no more than a rough idea. Their main value is to point in the direction one should go. The first trial sample gives a result that is not quite acceptable; how can it best be modified?

After two introductory chapters defining inductance, a.c. resistance, and Q, in relation to series and shunt equivalent circuits, and dealing with the effect of self-capacitance, the calculation inductance and losses of air-cored coils is treated. The design of stranded wire is an original contribution by the author, who then goes on to deal in turn with coils having laminated and dust cores. The self-capacitance of coils is the subject of a short chapter. The results are then applied to the problem of Q and its variation with dimensions and frequency. Harmonic distortion and impedance measurements are then discussed; and finally there are some numerical examples of how typical design problems might be solved.

The treatment is on the whole clearly and logically presented. One could wish that wherever the author had fallen back on "it can be shown" he had provided a reference. A list of symbols would also have been a great help. "Qo" appears on p. 45 without a clue to its meaning (until p. 108, and there both the nomenclature and the equation disagree with the earlier chapter referred to). Errors are rather disconcertingly frequent; for example, equation 34 is wrong by a factor of 4, and is by no means in its simplest form; and the *Proc. I.R.E.* reference at the foot of p. 147 is 10 years out. Notwithstanding these criticisms, the book can be highly recommended.

M. G. S.

CLUB NEWS

Bexley.—Meetings of the North Kent Radio Society (G3ENT) are held on the second and fourth Mondays of the month at 7.30 at the Freemantle Hall, Bexley. Sec.: L. E. J. Clinch, 8, Windsor Road, Bexleyheath, Kent.

Coventry.—Among the subjects to be dealt with at forthcoming meetings of the Coventry Amateur Radio Society, which are held on alternate Mondays at 7.45 at the B.T.H. Social Club, Holyhead Road, are "Top Band Transmitting" and "Super Modulation." Sec.: K. G. Lines, G3FOH, 142, Shorncliffe Road, Coventry.

Edinburgh.—Arrangements made for members of the Edinburgh Amateur Radio Club, who meet on Wednesdays at Unity House, 3, Hillside Crescent, include a lecture on "U.H.F." and a visit to the local Police radio station. The club's transmitter GM3HAM is in operation on 80 metres, c.w., on alternate Wednesdays. Sec.: D. A. E. Samson, GM3FQY, 56, Elm Row, Edinburgh, 6.

Richmond.—Meetings of the Richmond & District Radio Society are held on Wednesdays at 7.30 at the Richmond Community Centre. Sec.: W. Crossland, 1, Spring Grove Road, Richmond, Surrey.

Southall.—Future meetings of the West Middlesex Amateur Radio Club, which meets on the second and fourth Wednesdays of each month, will include an exhibition of home-constructed gear and a general discussion on "My Interest in Radio." A morse class is held for half an hour prior to each meeting. Sec.: P. F. Blundell, G3UOH, 213, Harrow View, Harrow, Middlesex.

Southwick.—The Southwick and District Radio & Television Club has been re-organized and weekly meetings are being held on Tuesday evenings at the "King's Head," Fishergate, Sussex. Sec.: E. Basillo, 111, Vale Road, Portslade, Sussex.

Sunderland.—At the meeting of the Sunderland Radio Society on January 11th at 8.0 in the Y.M.C.A., Toward Road, R. V. Dunsbury will speak on "Hams Abroad." Sec.: C. A. Chester, 36, Westfield Grove, High Barnes, Sunderland.

Wakefield.—A series of Mullard film strips covering the characteristics and applications of valves are being shown to members of the Wakefield and District Amateur Radio Society. Meetings are held on alternate Wednesdays at 7.30 at Service House, Providence Street, Wakefield. Sec.: W. Farrar, G3ESP, "Holmcroft," Durkar, Wakefield.

Watford.—Lectures on radio fundamentals and the early history of television will be given at the meetings of the Watford and District Radio and Television Society on the first and third Tuesdays in January and February. Meetings are held at 7.30 at the Cookery Nook, The Parade, Watford. Sec.: R. W. Bailey, G2QB, 32, Cassiobury Drive, Watford, Herts.

Thorn Gramophone Needles

Their Use in High-fidelity Reproducing Equipment

By A. M. POLLOCK

MANY readers will have followed with interest recent investigations[1] into gramophone record and stylus wear, illustrated with photomicrographs by C. E. Watts. The general conclusions seem to favour the sapphire-tipped stylus (after the diamond, which is beyond the financial reach of many), to the exclusion of most other types. The thorn needle is usually dismissed very briefly on the ground that it is composed of a material too soft, quick-wearing and compliant to be suitable for serious use, these alleged weaknesses being demonstrated by a distinctly discouraging photomicrograph of a very worn and blunt "instrument."

Now there are still many music lovers and gramophone owners who continue to use thorn needles of the miniature variety with modern high-fidelity apparatus, and who are just as concerned as their engineering brethren in achieving as realistic reproduction in the home as possible. They use thorns because under proper conditions there is no loss of useful "top" and their records reveal none of that distressing deterioration in sound quality caused by the kind of wear that seems to have been unavoidably associated with metal and semi-permanent styli. This latter factor is obviously of the very greatest importance to the serious record collector and is, no doubt, the strongest reason still for using this type of needle. It is hoped to show that the practice is not incompatible with genuine high-quality reproduction and to suggest possible reasons for this.

Before going any further it might be as well to be a little more precise about the expression "no loss of useful top" that has been used in the preceding paragraph. In the majority of records, even new ones, a slight top cut seems to be necessary with thorns, as with other styli, to keep surface noise down to normally acceptable limits and/or to maintain musical balance. The rising recording characteristic used by Decca, of course, requires this at reasonable volume levels if high-frequency reproduction is genuinely straight-line. As those who have worked on the problem know, it is only rarely that a really straight-line system can be used "flat out" with commercial records, and it seems clear that, if all the other elements in the chain are satisfactory, the thorn for its part can give a wider range than can generally be utilized. If, therefore, the high-frequency response of the thorn needle could be further improved it seems likely that no useful purpose would be served, because the resulting increase in surface noise and/or unnatural brilliance would have to be offset by additional top cut. The aural results with a thorn in a suitable pickup (using the same amplifier and loudspeakers) are difficult to distinguish from those obtained from a popular modern high-fidelity pickup incorporating a sapphire stylus. The principal difference is a slight change in the pitch or quality of the surface noise but little in the amount.

Test Conditions

As quality and realism in sound reproduction depend on all the links in the chain of reproduction, as well as on the stylus, it might perhaps be useful to say that the writer's results were obtained using a 12-watt push-pull triode amplifier with 20db negative feedback from output transformer secondary to input, very low distortion pre-amplifier with negative feedback, moving-coil pickup and dual speakers with crossover, the last reproducing at least up to 15 or 16 kc/s, the limit of two listeners' aural sensitivity. It is also appreciated that, to the extent that these remarks are based on subjective observa-

[1] "Record and Stylus Wear," by G. H. H. Wood, *Wireless World* July, 1950.

Fig. 1. Sapphire stylus with 0·0025-inch tip radius.

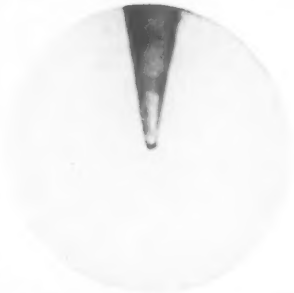


Fig. 2. Freshly-pointed thorn needle before use.

Fig. 3. Thorn point after playing three sides of 12-inch record.

tions, they cannot expect to be accepted as conclusive evidence of physical facts, and obviously no quantitative claim can be made. The whole question is nevertheless so closely bound up with the effect of the reproduced sound on the individual that it is thought that the comparisons will still be of some value. It is perhaps a matter of interest that a frequent reaction of friends hearing demonstrations of thorn reproduction on the above equipment is to observe that the high-frequency response is markedly greater than their own equipments provide, using high-quality lightweight pickups with sapphire styli. This, of course, proves nothing about the comparative merits of the two types of styli by themselves, but it does show that the thorn can reproduce up to a higher frequency than those particular listeners are normally satisfied with.

In the latest pickup and stylus developments stress has been laid on the very great importance of minimizing the mass and damping of the moving elements and the downward pressure on the stylus point. These factors are of course to a large extent interdependant, but when the last can be reduced to 14 gm and less it has been found that both record and stylus wear decline to a surprising degree. Mr. Wood's interesting article in the July issue makes it clear how the sapphire stylus benefits from reduced weight on the point.

Just as with sapphire styli, it has transpired that miniature thorns improve very strikingly in important characteristics if the various pressures they are subject to in playing can be effectively reduced. Used in a moving-coil pickup with very light lateral damping and 14-gm needle pressure it was found that up to six sides of 12-inch (78 r.p.m.) records could be played without any noticeable deterioration in quality. Figs. 2 to 4 show photomicrographs of an unused thorn point and the wear suffered with 14-gm pressure after playing three and six sides of fairly new copies of Decca's "Le Tombeau de Couperin" and "Fire-bird Suite," both really first-class recordings. Fig. 5 shows a thorn after playing both sides of a nearly two-year-old "Danse Macabre" (Decca), under the same conditions. All the illustrations are enlarged to exactly the same degree and it is therefore possible to estimate the extent to which the wear to the thorn point has caused its size to expand in relation to the standard sapphire. In no case does the point appear to have become larger than that part of the sapphire which is in contact with the record groove. It will be realized that the thorn tip is worn to a combination of two shapes, a chisel shape in the direction along the groove and a vee shape in the direction across the groove. Fig. 5 shows more clearly than the others the chisel shape to which the point becomes worn due to running on the bottom of the groove. The left-hand side is the trailing edge and the right the leading edge.

It will be observed that the thorn point is a good deal more acute than the usual sapphire tip, and the writer has found that much of its success depends on this fact. Not only are the higher frequencies reproduced very much better with a fine point, but with a comparatively long thin one quite a reasonable life can be expected before the part of the needle in contact with the groove becomes too big to reproduce without noticeable distortion. Such a small needle point is, however, contrary to normal design practice as applied to sapphire styli and it will be useful to see whether any explanation can be offered for this conflict.

Fine Points

The reasons advanced for the 0.0025-in radius point are too well known to require repetition here, beyond saying that one object is to obtain continuous contact between the stylus tip and both walls of the groove. It may not be quite as well known that this object is, in fact, rarely if ever achieved under playing conditions, and those who are interested in following up the investigations which have been made are referred to the December, 1949, issue of this journal, p. 497, which contains an illuminating report of some of Mr. C. E. Watts' work in this connection. Mr. Watts' microscopic examinations under playing conditions, particularly when loud passages of music were involved, showed that continuous contact between stylus and groove walls was certainly not obtained in his experiments, but that, somewhat surprisingly, this did not appear to result in any distortion that could be detected by critical and experienced listeners. Without attempting any precise mathematical assessment it seems very likely that quite appreciable forces are involved in trying to accelerate a hard inflexible stylus through the wave amplitudes concerned in as short periods as from one-twentieth to one ten-thousandth or less of a second, and that it is perhaps not entirely surprising that practical styli cannot be so driven with complete success. Instead they may well ride up slightly in the groove, or, alternately, press into the wall that is

Fig. 4. Thorn point after playing six sides of 12-inch record.

Fig. 5. Thorn point after playing both sides of Decca "Danse Macabre."

Fig. 6. Thorn point after playing one side of 10-inch long-playing record.

exerting pressure on them, so causing gaps to appear between the stylus point and the opposite wall of the groove. From the foregoing it would therefore appear that the important factor in this question of continuous contact between stylus and groove walls is the degree to which "looseness" occurs rather than the fact that it does occur at all.

Coming back to the fine thorn point it seems clear that the extreme tip will very rapidly be worn to the contour of the bottom of the groove and may thus fit it well enough as long as the total damping and inertia, as reflected at the needle tip, is light enough not to prevent the needle tip from following the lightest guidance from the groove. At the end of its life, before re-sharpening, the thorn point has worn large enough to fill the groove to the maximum allowable extent before distortion becomes apparent and it seems probable that it reaches the minimum size for sufficient fit very quickly after being put into use. One advantage of the fine point would appear to be that it will be less subject to "pinch effect."

To a possible criticism that a long very acute point on a thorn will tend to increase the pliability of the thorn material, which was one of its main weaknesses in the old heavyweight pickup era, it might be answered that the amount of "bending" of the thorn needle, under the influence of the recorded vibrations, will surely be a function of the damping, mass and inertia of the moving parts it has to drive. Provided these load factors are small enough there seems very little to bend the thorn against.

However, even if it is accepted that the thorn does flex slightly under the influence of the highest frequencies, it seems not inconceivable that it may still be a good medium for transmitting to the voltage-generating element transverse vibrations induced in it by the record groove, in the same way that paper loudspeaker cones successfully transmit complex waves from their apexes to their peripheries up to really high frequencies. The analogy between cones and styli must not be carried too far, of course, because the whole surface of the cone (more or less) is radiating the sound we hear, whereas the stylus is not. Nevertheless it may be legitimate to suggest that just as metal cones, used as direct radiators, i.e., not horn-loaded, result in more prominent resonances (*vide* Briggs, "Sound Reproduction," 2nd ed., p. 66) compared to paper cones, it may perhaps be that metal shafted semi-permanent styli are also subject to more pronounced natural resonances, if and when they vibrate in wave motion, than the softer and lighter thorn. These thoughts are offered as no more than possible theories to explain the surprisingly good performance of thorn needles, when most of the generally accepted factors making for good reproduction are apparently against them.

Long-playing Records

In connection with long-playing records, it may be of interest to the experimenter to note that the writer has been able to obtain excellent reproduction with a very finely pointed thorn, used in the pickup referred to above, but with the weight reduced to 5 or 6 gm. One thorn under these conditions will play one side of a 10-inch record without noticeable deterioration. One 12-inch side is just within its capacity though there is a tendency towards a slight falling off in quality right at the end, depending largely on one's success in producing a really fine point initially. The decline is not serious, but it can be distinguished. As might be expected, a certain amount of care is essential in inserting the finely pointed thorn into the pickup. Fig. 6 shows one of the thorns after playing one side of a 10-in L.P. record. The writer was not able to photograph it with a 0.001-in radius sapphire for comparison, but again some idea of its final size can be estimated by reference to the other photographs. The particular advantage of using thorns in connection with L.P. records is that one pickup head can be used for both L.P. and standard 78 r.p.m. records, as long as the downward pressure is variable within the appropriate range.

Record Wear

A further criticism of thorn needles has been that they wear records quite appreciably by picking up dust in the grooves and holding it, turning themselves into a kind of abrasive instrument. It is naturally not easy to get direct visual evidence of this fact one way or the other, and the frequent changing and sharpening of thorns would be no joke if one seriously attempted endurance tests. The record would most probably endure longer than the tester. The writer unfortunately is not in a position to offer any photographic evidence of records before and after playing with thorns in lightweight pickups, but it can be reported that the aforementioned "Danse Macabre," after some fifty playings exclusively with thorns in the moving-coil pickup referred to, still plays indistinguishably from new (the comparison, of course, being made against recent new records). Most keen record collectors take the trouble to brush their records before playing in an attempt to remove as much dust as possible, and it therefore seems likely that abrasion by dust held by the thorn, if it exists, can be reduced to negligible proportions if light pressures are used and the point itself is kept down to minimum size for tracing accuracy at high frequencies.

As has been said, and on the lessons of bitter experience, thorn users will take a lot of convincing that their needles do not result in minimum record wear, whatever the thorn's other shortcomings. If lightly damped pickups with needle pressures in the region of 14 gm are used in conjunction with properly shaped thorns it seems likely that even longer lives can be expected from records than has been the case in the past, allied to reproduction of a very high order.

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P.M. Focus Units, Elac Mark II, described briefly in a leaflet from Electro Acoustic Industries, Ltd., Stamford Works, Broad Lane, Tottenham, N.15.

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Radio-telephones and their applications described in a well-illustrated catalogue from Pye, Ltd., Radio Works, Cambridge.

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VOLTAGE

By "CATHODE RAY"

What is the Difference Between an E.M.F. and a P.D.?

THE word "Voltage" is a general term covering both electromotive force (e.m.f.) and potential difference (p.d.). Most of the books that teach electrical principles emphasize the importance of distinguishing between these two things. One reason why e.m.f. and p.d. tend to become confused may be because they are both measured in volts. Not in itself a very good reason, surely; nobody finds it difficult to distinguish between tomatoes and parsnips because they are both sold by the pound. The chief difficulty, probably, is that neither e.m.f. nor p.d. can be seen, and many of the necessary circuit calculations can be done quite successfully in terms of "voltage," so why bother?

The answer is that the ability to cope with the trickier problems in electricity depends on a clear mental picture of what goes on. And a clear mental picture of an electrical circuit is impossible with only a hazy idea of "voltage."

This distinction between e.m.f. and p.d. is one of the most difficult of the basic ideas to grasp. Or so I think. A useful working picture of it can be formed by any reasonably intelligent student in a few minutes. But later on he may wonder if the dividing line is quite so clear-cut as it seemed at first.

Morecroft's Distinction

These thoughts came into my mind when I happened to turn back to an old guide and counsellor—Morecroft's "Principles of Radio Communication," dated 1921. This book has stood the test of time much better than many that have been written since. Only the other day I read a post-war article (War No. 2; not No. 1!) in which the author stated very cocksurely that whatever else might happen the signal current in the anode circuit of a valve must always be in phase with the grid voltage. If he had looked up his Morecroft he would have spared his readers this misdirection, for the contrary is shown not only in theory but backed up by photographed oscillograms from actual circuits. And this author evidently had Morecroft handy, because he referred to his teaching on e.m.f. and p.d. That was how I came to look it up.

Curiously enough, it was just here where for the first time I wondered if Morecroft hadn't slipped just a little. He illustrated the distinction with two diagrams (reproduced here as Fig. 1), one of them showing a current being maintained through a resistance by a battery—a source of e.m.f.—and the other a momentary current passing through a wire joining two balls, one charged positively and the other negatively and therefore having a p.d. between them. Regarding the latter Morecroft says, "There is no action taking place which tends to maintain the difference of potential between the two balls; such a combination does not generate an electromotive force."

Now, I suppose that strictly according to the wording of this it is perfectly correct. That is, if the emphasis is on "maintain" and "generate." My only objection is that as the chosen example for illustrating the difference between e.m.f. and p.d. it is likely to lead the reader to suppose that in the charged-ball system there is no e.m.f., and especially that the distinguishing feature of an e.m.f. is its ability to maintain the flow of current for a relatively long time, as a battery does. (Do I hear cries of protest from owners of battery-driven sets!)

I am not using this quotation for the purpose of trying to show how much cleverer I am than Prof. Morecroft. Far from it; if everything I had written in the last thirty years could bear such close scrutiny now as "Principles of Radio Communication," I might really have something to boast about. No; it just happened to set going some thoughts on exactly what are the distinguishing marks of an e.m.f. This is not just technical hairsplitting or armchair theorizing; one of the most useful practical "laws" in circuitry is Kirchhoff's second, which in its most usual form says that if you add up all the e.m.f.s round a circuit (with due regard for + and − if there are any opposing one another), and also add up all the potential drops due to resistance, the two totals will be equal. And there is this important point, that the "sign" (+ or −) of a p.d. depends on the direction of the current, but that of an e.m.f. does not. So one really ought to be able to tell with certainty which is which.

P.D. Without an E.M.F.?

In purely d.c. circuits, with only resistances and batteries, there is no real difficulty. Anybody who has had the elements of the matter explained to him should be able to see that the voltage between the terminals of a battery when it is supplying current is not the e.m.f. of the battery (nor, to satisfy the legally-minded, is it even equal to the e.m.f. of the battery), because there is a voltage drop inside it due to its own resistance and this drop is deducted from

Fig. 1. Is it fair to use these examples to illustrate the difference between e.m.f. and p.d.?

the e.m.f. to give the terminal voltage. The only thing that might start an argument here is the question of whether it is possible to have an e.m.f. without a p.d., or vice versa. A dead-shorted battery might possibly qualify as an example of the former. And Morecroft seems to give the charged balls as an example of a p.d. without an e.m.f. But that is going beyond a d.c. circuit in its strictest sense, by bringing in a capacitance.

Well, let us bring it in. I think we can agree with Morecroft that a pair of stationary oppositely-charged balls—or capacitor plates—cannot *maintain* a p.d. steadily while it is causing a current to flow, and does not *generate* an e.m.f., if that must be understood to mean returning the positive charges that have reached the negatively-charged ball back by a different route to the other ball, there to continue through the conducting path to keep the current going. His charged capacitor can be likened to a switchback in which the cars have, by some means unspecified, been lifted to the upper stage. From there they can "flow" to ground level around the track "circuit." And then the movement stops. To maintain the flow of cars, a source of power is needed to return the cars against the force of gravity to the upper or "high potential" level. Morecroft would no doubt explain that this power lifting gear is the "e.m.f.", without which the flow of cars ceases when the original "charge" has reached the ground. You can, if you prefer, substitute a filled reservoir on top of a hill to represent the p.d. and a pump to represent the e.m.f. Either way it seems to clinch the matter pretty definitely and clearly.

But wait! Let us approach the thing from a different direction by a rather roundabout route and see how it looks.

The most important sources of e.m.f., it will be agreed, are not batteries but electromagnetic generators. Now continuity of voltage is not at all a characteristic feature of this method of generating an e.m.f. To make it continuous necessitates an elaborate system of multiple poles, distributed armature windings, innumerable commutator segments, and brushes. Even then there is a ripple. So electrical engineers have more or less given that up and standardized on power systems delivering voltage in alternate positive and negative pulses each lasting only a hundredth of a second or thereabouts; less time perhaps than our "momentary" capacitor discharge. So the mere length of time that a steady current flow can be maintained hardly seems to be the proper criterion of an e.m.f.

True Mark of an E.M.F.

A more fundamental basis for identifying e.m.f. is by considering the transfer of power. In a power station it is abundantly obvious that the generators are giving out electrical energy in exchange for mechanical energy. We learn that there is a fixed rate of exchange. To raise the potential of an electric charge so that the charge can flow through the circuit resistance necessitates the expenditure of some kind of energy. In fact, the real measure of an e.m.f. is the amount of energy that is put into the charge. If a charge of one coulomb is given an energy of 100 joules (= watt seconds), then the e.m.f. doing it must be 100 volts, and to generate this electrical energy 100 joules of some other sort of energy must be spent. (The usual answer, that one volt is the e.m.f. required to drive one amp through one ohm doesn't really define voltage, as you discover later when you have to define resistance and find yourself in a vicious circle.)

In an electrical generator the e.m.f. is produced by moving a magnet. If the e.m.f. acts in a closed circuit so that it causes current to flow, then the current sets up its own magnetic field, and it is the mechanical force needed to move the magnet against the attraction or repulsion of this field that demands an input of mechanical energy. The fact that the e.m.f. only lasts as long as the possibly brief moment that the magnet is kept in motion relative to the circuit does not in any way disqualify it from being an e.m.f.

As we all know, it makes no difference whether the magnet is a permanent magnet or an electromagnet, and if the latter then it is not necessary for it to be actually moved—a change in strength of magnetism is enough. In this case the input of energy can be of the same kind as the output—electrical—yet I imagine nobody would say that all the books are wrong in speaking of the induced *e.m.f.* Anybody who, like me, had just said that e.m.f. is a result of the expenditure of some other kind of energy could easily talk himself out of any criticism by pointing out that there is a double conversion of energy in this case; first from electrical into magnetic, so that the immediate cause of the e.m.f. is an expenditure of magnetic energy.

Squaring up Kirchhoff

This argument holds even if the input and output circuits are the same, giving *self*-induction. It may be worth thinking this out in some detail. Consider the arrangement shown in Fig. 2(a), in which all resistance except R is negligible. If S_1 is now closed (b), a current flows, of strength I equal to E/R. Or, as Kirchhoff would put it, the p.d. IR, between *c* and *d*, is equal to the e.m.f. E acting from *a* to *b*. Neglecting the inductance of the leads, etc., the current jumps to its full value immediately the switch is closed. If now S_2 is also closed (c) the voltage E is placed across the inductance L. Since L has no resistance, the ultimate current would theoretically be infinite; but directly any current starts to flow it sets up a magnetic field around the coil, and the growing field generates an e.m.f. E_L that tends to oppose the growth of current. This e.m.f. must obviously be equal to E. So the rate at which the current grows is such as to make it so. If L is in henries, the required rate is E/L amps per second. There is no IR drop in the battery-and-coil circuit, but also there is no net e.m.f. ($E - E_L = 0$), so Kirchhoff is satisfied.

While current is flowing through R, the electrical energy put into it by E against the resistance is being converted into heat energy. The electrical energy put by E into the L branch against E_L must also be going somewhere; it is being stored as magnetic energy.

Next, suppose that after the current through L has grown to a substantial number of amps, S_1 is opened (d), cutting off the source of e.m.f. The current through R from E instantly ceases. But the current through L cannot instantly cease. If it did so, the strength of magnetic field would cease with it, and induce an infinitely high voltage across the resistance, which if it weren't absurd would be highly

interesting. What actually happens is that the current diminishes gradually, and the resultant diminishing of the magnetic field generates an e.m.f. in the opposite direction, from *e* to *f*, driving current in the same direction as before through L, but in the opposite direction to the original through R. Applying Kirchhoff, we now have E_L equal to the p.d. across R. As the current falls, so does this p.d., and so does the e.m.f., and so does the rate at which the current falls. So it gradually tails off, just like the current discharge of a capacitor.

Just like the current discharge of a capacitor. Perhaps you were forgetting Morecroft's brass balls in Fig. 1. We have nearly worked our way back to them. Can anybody deny that E_L in Fig. 2 was an e.m.f.? It even has a full official title—the e.m.f. of self-induction. Without it there would be no end of a job squaring up old Kirchhoff. From the energy transfer point of view, too, E_L ranks as an e.m.f.; magnetic energy is disappearing and an equal amount of electrical energy is being created; this in turn being converted into heat energy in R.

Now go through the whole Fig. 2 process again, substituting a capacitor C for the inductor L. There is no need for me to describe it in detail. The main thing is that a certain amount of energy will become stored in C as an electric field, and in the final event this stored energy will develop a voltage which will drive a tailing-off current through R. The two cases are so closely parallel that I for one would not care to deny the driving force for this current the title of e.m.f. The only argument even a prosecuting lawyer could try would be to claim that in the case of the discharging capacitor the source of energy is an *electric* field, so that there is no conversion to electric energy from a different kind. And although an analogy isn't strictly evidence, what about the switchback?

The defence would then point out that the switchback with its raised cars can, even without a driving engine, lift weights from ground level. All one needs

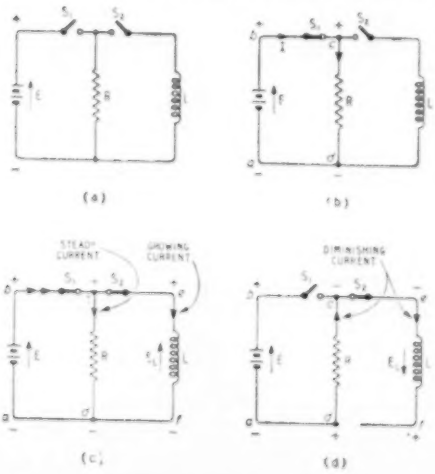


Fig. 2. Sequence of switching in an imaginary experiment to shed light on the difference between e.m.f. and p.d.

is a pulley arrangement, whereby the raised cars can be allowed to fall and the energy so released is capable of raising other cars (admittedly not so heavy, owing to frictional losses). The fact that this process cannot be kept up indefinitely makes no difference in principle. As a matter of fact, a Wimshurst machine is an example of how a capacitor discharge *can* be kept up continuously, by the expenditure of mechanical energy. Even if the argument about the electric field not being a different kind of energy from the electric current were sound—which is distinctly doubtful—it would not only make the discharging capacitor circuit a very awkward customer for Kirchhoff's second law; it would also be a very inconvenient point of order to press, for it would mean upsetting the beautiful balanced pattern of two opposite kinds of reactance. A.c. would be opposed, in inductive reactance, by the *e.m.f.* of self-induction—and in capacitative reactance by heaven knows what. Wherever the dividing line is to be drawn between e.m.f. and p.d., please don't let it be here. It would be about as unhappy as the 38th parallel in Korea.

Cause-and-Effect Fallacy

Where *should* the distinction be drawn? I warned you that this question was not going to be quite so simple as it is sometimes made out to be. But if you must ask, I would say that an e.m.f. is present only where the exchange of energy in the circuit is reversible. The voltage across a resistance is a p.d., set up by the operation of an e.m.f. somewhere else, but not itself an e.m.f., for no part of the electrical energy which is being lost in the resistance as heat can be directly restored to the circuit by the resistance. But when electrical energy is used to run a motor or charge a battery or magnetize a coil—or charge a pair of brass balls—a back-e.m.f. is set up which is capable, given suitable conditions, of reversing the energy transfer.

I looked up all the books I could lay my hands on, and all except one were careful never to mention e.m.f. in connection with a discharging capacitor. Why?

A broad difference is that e.m.f. is a cause; p.d. the effect. On this basis it might seem right to say that the charge on the balls is the effect of an e.m.f. that must have been exercised previously—and therefore not itself an e.m.f. But those few added words, in my opinion, are just where the fallacy lies. For, you see, an effect can in turn be a cause. When you pump your bicycle tyre you exert an "air-motive force," and the result is a pressure difference between the inside of the tyre and the outside. Nothing but such a force could make the air more against the internal pressure. But this effect, this "p.d.", could in its turn be used as an "a.m.f." to inflate a toy balloon.

So is there any need to be so shy about calling the voltage across a charged capacitor an e.m.f.? The main thing, of course, is to be quite clear in one's mind. What we call it is not quite so important. Calling the funds expended on entertaining lady friends "expenses" may not prevent a man from understanding quite clearly what he is doing. It may (for a time) mislead other people. It may (in time) even mislead his own judgment. The best thing is not only to understand things clearly but to express them so that everybody else knows what is meant.

Some of the things one hears about voltages don't quite come up to this ideal. We all know the newspaper paragraph reporting that "10,000 volts passed through his body," followed by a statement on the subsequent lamentable condition of the said body. And when someone tells us that he got a shock of about the same voltage from his sparking plug without any such dire results, he is likely to account for it by saying that "of course there wasn't so much current behind it." Such statements are liable to confuse seekers after true knowledge, who find difficulty in reconciling them with Ohm's Law. Are there different kinds of voltage, some of which are more hurtful than others? The question crops up a good deal now in connection with television sets. Some of these, we are told, are liable to cause a death in the family if handled internally before switching off, while the recent types, in spite of delivering somewhat higher voltages, are more or less harmless.

It is true that the effect on one's body of maintaining a given voltage across it depends not only on the voltage but also on its duration. Whereas a 1 μF capacitor charged to 2,000 volts can give a dangerous shock, a few pF charged to the same voltage is quite harmless because it is all over so quickly. Even if the brief voltage is continually repeated, as from a r.f. source, the result is heat rather than shock. That alone would explain the relative harmlessness of those few television models that derive their e.h.t. from a r.f. oscillator. But in these and also the popular "flyback" types the fact is that if your body becomes an unintentional load resistor in the circuit the voltage is just not maintained. The internal impedance of the source is so high compared with that of the body that most of the available voltage occurs across it, and you receive only a low voltage. The idea that you are standing thousands of volts is therefore quite wrong.

Transmission Through Tunnels

Characteristics and Performance of Metre and Decimetre Waves

By J. B. LOVELL FOOT, A.M.I.E.E. (General Electric Company's Research Laboratories, Wembley).

DURING the past year a series of tests has been carried out by the Research Laboratories of the General Electric Company to determine the propagation characteristics and behaviour of decimetre radio waves in railway tunnels. The practical applications of this work have still to be decided, but the subject is of sufficient general interest for an examination at this stage of the more important results obtained.

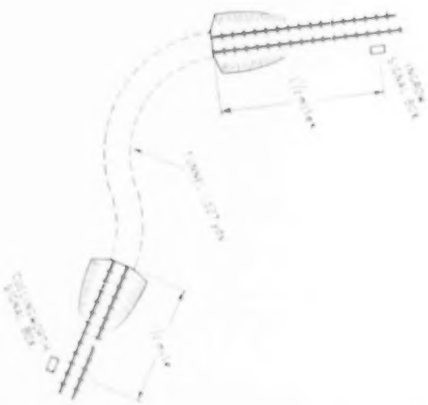


Fig. 1. Lees Moor tunnel where the tests on 82 Mc/s were carried out.

The tests to be described are a continuation of earlier work carried out in the metre-wave band, one of the objects of which was to determine a system suitable for communication between a moving train and signal boxes. Although long tunnels on main lines are relatively infrequent in this country, it is the comparatively small stretch of track through the tunnels that presents the greatest technical difficulty. Any radio system must be capable of operation without interruption, and communication from within a tunnel is of considerable importance. The chief interest is consequently centred on the problem of how this can be provided.

The Keighley district of Yorkshire was chosen for the original metre-wave tests, since the track here is one of the most difficult stretches in the country to cover by radio. Part of the route includes the Lees Moor tunnel, which is 1,527 yards in length and curves considerably (see Fig. 1). At the northern end, the Ingrow signal box is about 1½ miles from the tunnel mouth and a further ½-mile separates the southern end of the tunnel from the Cullingworth signal box.

Two 10-watt f.m. transmitters operating on a frequency of 82 Mc/s were installed with receivers at these two signal boxes and omni-directional aerials were mounted 20 ft above the ground. A similar equipment was placed on a platelayers' trolley which had an aerial fitted on the back. Communication between the signal boxes was satisfactory over the intervening hill but, between the mobile set and either of the fixed stations in the signal boxes, signals became too weak for satisfactory communication when the trolley was taken into the tunnel

for more than 15 yards. The signal box equipments were then taken to positions 20 yards inside the ends of the tunnel. The aerials were mounted on 7-ft tripods and placed in the middle of the track. It was now found, by moving the set on the trolley, that the distance of penetration for satisfactory signals was increased to 600 yards.

From these results it was concluded that three relay stations—one placed near the middle and one at each end of the tunnel—would be required to give reliable communication over the whole distance. At the time the tests were made, it was thought that the high attenuation of signals in the tunnel was mainly due to a screening effect between the transmitting and receiving aerials produced by the curvature of the tunnel walls. Subsequent tests carried out in a straight tunnel at Watford, however, have shown that the limiting distance is dependent more on frequency than on the curvature of the track or the transmitter power. The maximum distance for satisfactory communication obtained in the Watford tunnel with a power of 10 watts and at a frequency of 82 Mc/s was no greater than that for the Lees Moor tunnel. It was therefore decided to make tests with decimetre-wave equipment when this became available.

Tests on 1,400 Mc/s.—The first of these tests was made through the straight Watford tunnel. This is a brick-lined double-track tunnel 1,800 yards long and is situated about 1 mile north of Watford Junction station. The equipment used for the test consisted of a pair of f.m. transmitter-receivers; the radiated transmitter power was about 0.5 watt at a frequency of 1,400 Mc/s and the receiver sensitivity for good communication about 10 μV. A compact type of directive aerial, consisting of separate transmitting and receiving dipoles mounted in a simple corner reflector, was used at each end. These aerials gave a beam width of about 40 deg (to points 6 db down) and a gain of 9 db compared with a simple dipole.

For the first test, the sets were placed with the aerials in the open at opposite ends of the tunnel and close to the bank by the side of the track. The aerials were directed towards the tunnel ends, a distance of about 40 ft (see Fig. 2). Strong signals were exchanged and it was at first suspected that some freak reflection was providing a path over the hill. The arrival of a train, however, proved that the radio frequency path was in fact through the tunnel. As the train proceeded from one end to the other, a series of about 6 fades occurred; this showed up as a background noise in the receivers during periods of low signal strength, but communication was not interrupted at any time. An audible howl was noticed in both receivers as the train entered the tunnel mouth, and this occurred again as the train emerged at the distant end.

It was next decided to make a test with one set mobile, and for this it was necessary to wait until the section of track would be closed to railway traffic. Some months later, the section was closed for a period in order to allow maintenance work to be carried out, and the equipments were again taken to the site. One set was placed at the northern end of the tunnel with its aerials mounted on a 6-ft tripod and placed between the tracks near the mouth of the tunnel, the other set was placed with its aerial on a trolley and wheeled into the tunnel from the southern end. During the tests a light engine and four trucks were standing in the tunnel. Strong signals free from any noticeable standing-wave effects were obtained. Simple dipole aerials without reflectors were tried and noise-free signals were still obtained. Satisfactory communication was also possible when the mobile aerial was placed within a few inches of the track, or close to the tunnel wall.

Having obtained strong signals inside the tunnel for the whole length it was next decided to run the mobile set into the open southwards towards Watford station, leaving the other set in the same position at the northern end of the tunnel. There was the expected fall in signal strength as the distance increased, but it was still possible to obtain satisfactory communication as far as the station platform, which is 1,800 yards beyond the tunnel mouth.

So far the 1,400 Mc/s tests had been carried out in a straight tunnel and under line-of-sight, or near line-of-sight, conditions, but it was now thought desirable to repeat them in a curved tunnel. For convenience the London area was chosen and a section of the Primrose Hill tunnel between South Hampstead and Chalk Farm stations became available during a diversion of traffic. This also is a double-track brick-lined tunnel; its length is 1,180 yards and it is considerably curved (see Fig. 3). Again one equipment was set up just outside one end as in the Watford trials, and a trolley was provided for the mobile set. The performance in this instance proved very similar to that obtained at Watford, and no noticeable increase in the attenuation due to the curvature was found to take place. In this case the track curved away outside the tunnel mouth behind a high brick wall towards Chalk Farm Station. When the mobile set was taken along

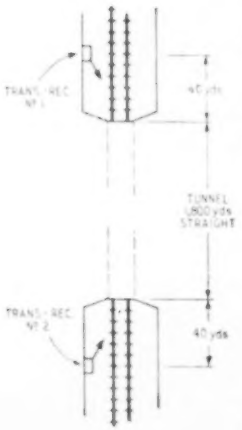


Fig. 2. Tests on 1,400 Mc/s were made in the Watford tunnel with the transmitters located outside as shown and the receiver mounted on a mobile trolley inside the tunnel.

Fig. 3. The Primrose Hill tunnel where tests were carried out on 1,400 Mc/s to study the propagation in curved tunnels at this frequency.

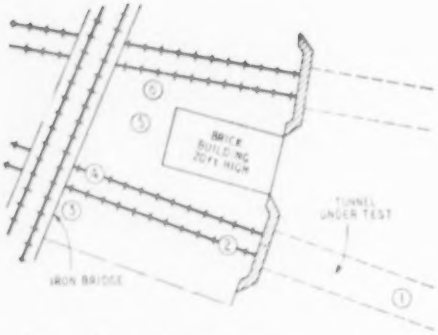


Fig. 4. The six alternative positions of the 460 Mc/s aerial (five outside the tunnel) from which the signal strength measurements given in the text were compiled. The receiver was at the distant (eastern) end of the tunnel.

here with the fixed equipment still at the distant end, a more rapid decrease in the signal occurred. The limit of good communication was at a point about 400 yards beyond the tunnel mouth and off the line-of-sight path.

Tests on 460 Mc/s.—There are many practical reasons why it is preferable to use the lowest possible frequency in any application for which transmission through a tunnel is required. In the first place circuits and valves can be more orthodox so that the equipment is cheaper to manufacture. Frequency control difficulties are eased if direct crystal control can be used and the power consumption is generally lower for lower frequency equipment. Against this, the size of the aerial is an important factor, for the aerial may have to be fitted to a train and clearances between rolling stock and the tunnel walls does not allow the attachment of a large aerial.

In order to assess these advantages and disadvantages, the next tests were made at a frequency of 460 Mc/s. In this range the radiator of a quarter-wave ground plane aerial is about 6in long only, and this could be fitted to a train without too much difficulty should propagation prove satisfactory.

Primrose Hill tunnel was used for the propagation trials. A transmitter was set up at the western end of the tunnel and operated from the supply mains. An omni-directional aerial was used and 70 ft of coaxial feeder provided to allow its position to be moved as desired. The equipment employed frequency modulation with a maximum deviation of 2.45 kc/s. The radiated power was 6 watts, and this could easily be reduced to 0.25 watt for the purpose of the trials. The receiver sensitivity for a usable signal was about 4 μV. Crystal control was applied to both the transmitter and the receiver local oscillator.

The transmitter aerial was first erected in the open, between the tracks 10 yards from the tunnel mouth. The receiver was placed with a simple dipole aerial on a trolley as in the earlier tests. As the trolley was moved relative to the transmitter aerial, the signal strength at the aerial terminals was estimated from readings of the limiter grid current in the receiver taken at frequent intervals. The experiment showed that strong noise-free signals were obtained throughout the tunnel length. A level of about 150 μV at the receiver at the western end, falling to 70 μV at the eastern end, was recorded and no noticeable standing wave pattern occurred, this being almost independent of the position of the receiving aerial. The trolley was then run out into the open at the eastern end where the track curved behind the high brick wall; here there was a more rapid decrease in signal strength though good communication was still possible at 200 yards beyond the tunnel.

With the mobile set returned to the eastern end of the tunnel, the position of the transmitting aerial at the western end was moved from the outside to a spot 20 yards inside the tunnel (No. 1, Fig. 4); the effect on the received signal at the eastern end was a reduction from 70 μV to 23 μV, or nearly as much as reducing the output power from 6 watts to 0.25 watts. This interesting result was unexpected; the explanation is not obvious and there would appear to be a field for further investigation. The transmitting aerial at the western end was finally taken further away from the tunnel mouth and a number of short tests were made with the radiator placed in positions indicated in Fig. 4. In the worst position (No. 6) a brick building screened the radiating aerial from the tunnel mouth, but in spite of this a 14-μV signal was received at the far (eastern) end.

The received signal with the aerial in the various positions was as follows:—(1) 23 μV, (2) 70 μV, (3) 74 μV, (4) 150 μV, (5) 25 μV and (6) 14 μV.

In conclusion, the work has shown that the lowest frequency for operation in a tunnel appears to lie between 82 Mc/s and 460 Mc/s. At the lower frequencies the tunnel attenuation is high and relay stations at intervals are required. At the higher there would appear to be no serious difficulties, though to go above 460 Mc/s would probably introduce more problems in the equipment and increase the cost.

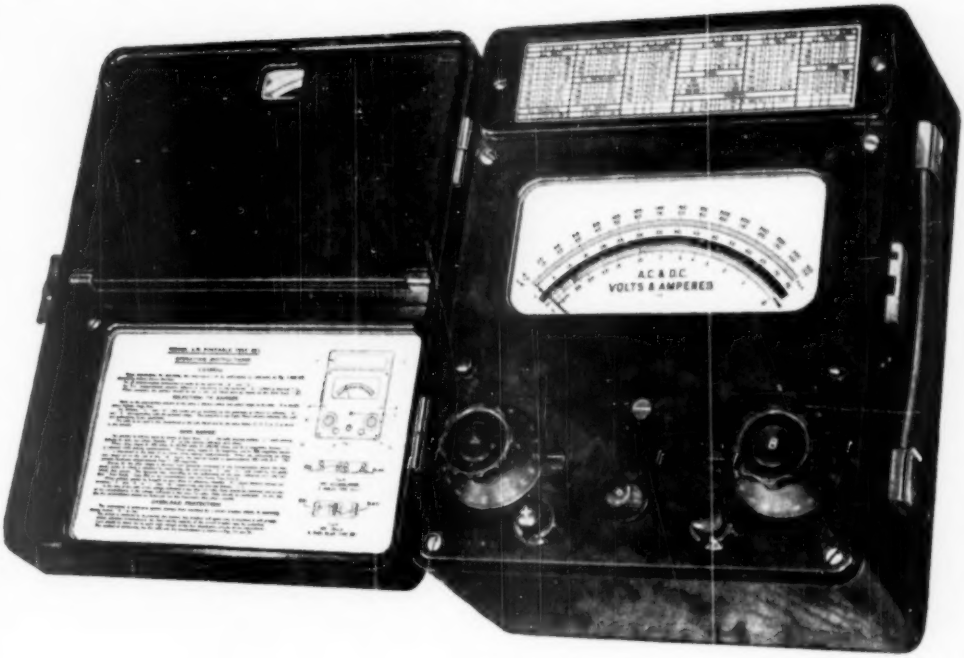
The choice of the aerial position on a train raises many problems, but the smaller size of the higher-frequency type is a great advantage. The possibility of mounting the aerial at axle level should not be overlooked since tests have shown a good field strength near the ground. This, however, may be ruled out owing to electrical noises produced by axles and wheels, and will certainly give poorer results when the train is in the open.

The author wishes to thank British Railways, whose helpful co-operation made the work described possible.

Colour Television in Trouble

JUDGING from technical journals recently received from America, opinion in that country has crystallized strongly against the decision to adopt the C.B.S. system of colour television. The F.C.C., as the responsible body, has come in for some hard knocks. *Tele-Tech*, in the November issue, characterizes the decision as "fantastic" and accuses the F.C.C. of taking steps never contemplated by those who framed the radio laws of the U.S.A. *Tele-Tech* maintains it is not in the public interest:—

To render obsolete 10 million existing sets.
To require future set buyers to spend \$30 to \$130 on gadgets they may never use.
To degrade picture quality and impose on the public a small-picture system.
To disrupt the entire television industry.
To divert to colour television components that are needed for the defence programme.



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12" Concentric Duplex with cross-over network and transformer, £15 . 15 . 0. Without transformer, £14 . 14 . 0.

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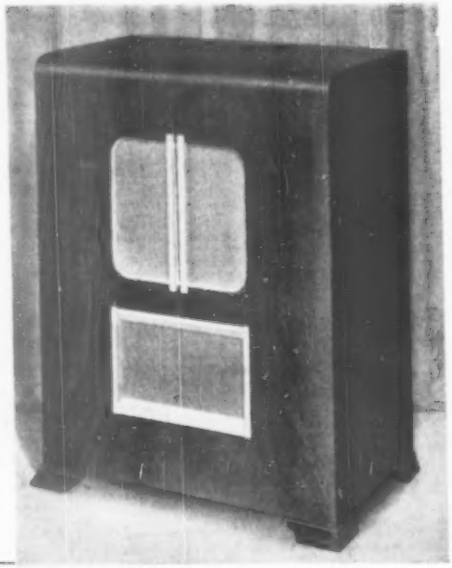

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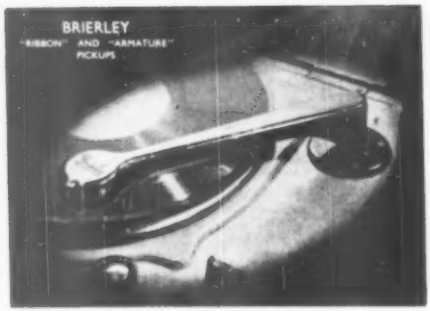

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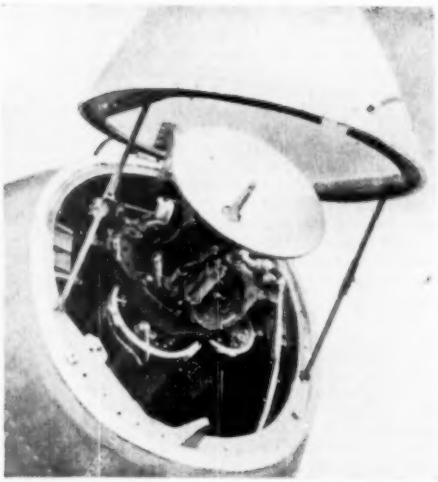
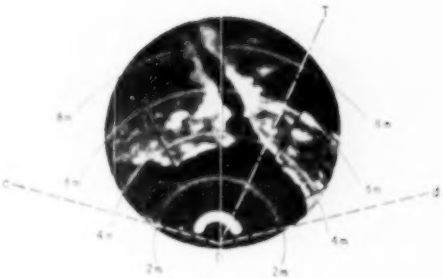


The scanner and associated equipment on its stabilized mounting in the nose of an aircraft.

OF all the types of cloud which make life difficult for an air pilot and unpleasant for his passengers, probably the worst are those known as cumulo-nimbus. They have a solid and threatening appearance which is due to their being composed of heavier water droplets than the more soft and misty cumulus clouds, and an aircraft passing through them usually has to put up with thunderstorms, static electricity and bad air pockets, all of which make the flight extremely uncomfortable. There has consequently been a definite need for some kind of device in the aircraft to give warning of cumulo-nimbus clouds and enable a course to be steered through them—particularly at night and in poor visibility—and in view of their considerable density, it is not surprising that radar has proved successful. Early wartime experiments showed that 3 cm was about the most suitable wavelength, and now a complete airborne equipment, using modern techniques such as sealing and pressurization, has been produced by the Electronics Division of Ekco (E. K. Cole, Ltd.) in conjunction with the Ministry of Supply. It has a p.p.i. display and therefore can also be used for "map-painting," as well as for giving warning of high ground and preventing those collisions which occur so often with the sides of hills and mountains. Trials carried out by B.O.A.C. on this equipment show that it has a range of up to 40 miles for cumulo-nimbus clouds and for coastlines with cliffs, up to 25 miles for medium-sized ships, and up to 12 miles for other (large) aircraft. Any clouds which do not give a good response when they are ten or more miles away are usually harmless.

The aerial system consists of an 18-inch parabolic reflector with a back-fed dipole and reflector positioned at the focal point. This produces a scanning beam which swings back and forth in azimuth, passing through an angle of 150° once per second. By way of illustration, Fig. 1 (a) shows how the entrance to Southampton Water would be scanned by an aircraft approaching from the sea, the beam S being swung through the 150° arc from C to D. At the same time, on the screen of the p.p.i. tube (b) the time-base T is swung in synchronism through a corresponding arc of 150°—as if it were pivoted at O at the bottom of the screen. It therefore traverses a wedge-shaped sector of the screen, *c* to *d*, corresponding to the wedge-shaped sector C to D on the map. The

(a)



(b)

Fig. 1. At (a) is a map of Southampton Water, showing how it would be scanned by an aircraft approaching from the sea, at 4 miles from point X on the coastline. At (b) is the actual p.p.i. display as seen in the aircraft.

trace of the time-base is normally kept invisible by a negative bias on the grid of the tube, but the radar responses are applied to it as brightening modulation. So, regarding point O as corresponding to the position of the aircraft, or zero range, the responses appear at various distances along T from O according to the actual distances on the map, and as T scans in synchronism with the search beam S a true representation of the coastline is built up on the screen. For the purpose of estimating distances, bright-spot markers are applied to the time-base trace at known intervals, and when scanning is in progress these appear as brightened arcs which indicate distances in miles from O. The range of, say, a point X on the coastline in (a) can be seen to be 4 miles because it appears on the 4-mile arc on the screen. When there are a number of radar echoes at short range the screen around point O tends to become congested and bearings cannot be taken with certainty, so a device has been fitted to enable the centre of the display to be opened out when required. The time-base sweep, instead of being initiated simultaneously with the brightening and marker waveforms, is started in advance. This time interval is adjustable, and the effect on the screen is that zero range is now represented by a small arc some way out from the centre, which is left clear. The time-base speed can be altered to give two ranges, 0-10 and 0-40 miles.

Circuit Arrangement

A general idea of the radar system, which follows conventional practice, can be gathered from the simplified block diagram, Fig. 2. The master timing pulse for the whole equipment is produced at a repetition frequency of 700 per sec. by the master pulse generator, a cathode-coupled multivibrator. On the one hand this pulse triggers a thyratron-controlled modulator and so the 10-kW magnetron, which generates a 1-μsec. pulse of r.f. energy at 9375 ± 30 Mc/s. At the same time, the master pulse also triggers the time-base generator and range-marker generator, thereby synchronizing them with the transmitted pulse. To obtain the back-and-forth scanning effect on the p.p.i. tube, the time-base waveform is fed through a magslip which is driven by the actual scanning mechanism of the aerial system such that the relative phases of its two outputs vary directly with the angular position of the radar beam. These two saw-tooth outputs in quadrature are then fed into two corresponding pairs of deflector coils placed at right-angles to each other on the p.p.i. tube, and the effect of the varying phases in this deflection system is to rotate the time-base trace about point O (Fig. 1) in accordance with the rotation of the radar beam about the nose of the aircraft. The whole process can be likened to a remote position control system in which mechanical angular movement is transformed into variations of electrical phases, only the coils at the receiving end, instead of transforming the phases back into mechanical movement by rotating an armature, are simply used for deflecting a c.r.t. trace.

The output from the magnetron passes through a wave-guide duplexer which permits the aerial to be used for both transmitting and receiving. In the receiving section of this duplexer are two mixer crystals coupled to a common klystron local oscillator. One of these crystals mixes the local-oscillator frequency with a small portion of the magnetron output and the difference frequency is fed to the automatic frequency-control unit, which controls the frequency of the local oscillator so that an i.f. of 45 Mc/s is always maintained in spite of drift in the klystron or in the magnetron. The other crystal mixes the received radar signals with the local oscillator and so produces i.f. signals which are detected, amplified and then passed to the p.p.i. tube as brightening modulation.

An essential feature of the equipment is that it enables the pilot to tilt the plane of the radar scan up and down from the horizontal to any angle within ± 10°. This is necessary in the first place, of course, to permit scanning of the terrain below. Secondly, it enables the pilot to estimate the height of clouds and high ground—and, in fact, a navigational technique for safe clearance of high ground has been worked out which depends on there being no p.p.i. responses within a certain range when the radar scan is tilted downwards at a certain angle.

The mechanism consists of a remote positioning servo system which tilts the parabolic reflector up and down with respect to the dipole. Aeroplanes, how-

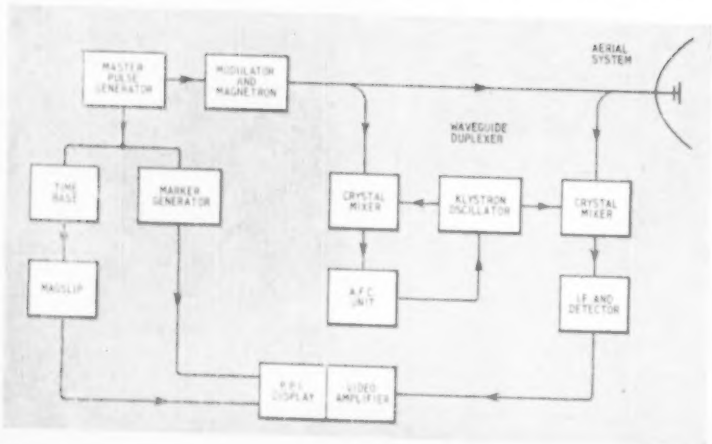


Fig. 2. Simplified block diagram of the radar system, the essential parts being the transmitter, receiver, frequency-control system, synchronized time-base, and c.r.t. display unit.

ever, cannot be relied on to remain horizontal for very long, and as this would normally make height estimation and map-painting impossible, it has been necessary to provide a stabilizing system to keep the scanner truly horizontal, irrespective of the position of the axes of the aircraft. The reference horizontal is provided by a gyroscope mounted with the scanner on a gimbal ring which can be moved about with respect to the aircraft. Two coils in the gyroscope provide electrical error-signals for aircraft roll and pitch, and these signals actuate a servo system which drives the gimbal ring so that it compensates for the aircraft movement and returns the complete scanner and gyroscope assembly to the horizontal. Once in the horizontal, or balance condition of the servo, the error-signals cease and the gimbal ring is left stationary. Also mounted on the stabilized gimbal ring are the transmitter-receiver unit and the servo-system unit, so that the number of wave-guide rotating joints and flexible cables required is kept to a minimum. If desired, however, the gimbal ring can be dissociated from the stabilization and locked permanently in a plane parallel to the axes of the aircraft.

The equipment will work satisfactorily up to an altitude of 25,000 ft when unsealed. Those units which are likely to be fitted in unpressurized parts of the aircraft, however, can be sealed and pressurized, and they will then operate up to 40,000 ft. All components are within their ratings at ambient temperatures up to +55° C and the equipment is unaffected by low temperatures down to −40° C. Its total weight is in the region of 150 lb.

Speech and Music

Preferred Relative Sound Levels Investigated by the B.B.C.

OPINIONS will always differ as to whether the B.B.C. modulates too deeply on speech compared with music (or vice versa), but there is little doubt that an optimum relationship exists, and some interesting results are given in a recent report* of research work undertaken by the Engineering Division of the B.B.C.

Originally, the object of the research was to establish quantitatively the known preference of musicians and programme engineers for listening at higher levels than ordinary listeners in the home, and to make due allowance for this when adjusting tonal balance. The results are summarized in Table A, and it is interesting to note the wide divergence in preferred levels between men and women programme engineers, particularly when listening to speech.

Subsequently, the investigation was extended to discover listeners' preferences in changes of level from one type of programme to another. Sixty subjects of both sexes, and ages varying from 15 to 65 years were asked to participate; and each test, consisting of thirty-six programme changes, included speech to speech, music to speech, speech to loud-starting music, speech to quiet-starting music and speech to the interval signal (Bow Bells). In each case the second programme was introduced at various levels up to 10 db above and below that of the first programme, which was set by means of an N.P.L. sound meter to the optimum level indicated by Table A. Listeners were given a score card and asked to mark each test "Too loud," "Too soft" or "Satisfactory." Results were averaged and plotted, and the conclusions summarized in Table B.

As might be expected, no change is indicated between the preferred levels of speech following speech, and these tests were introduced primarily as a check on the validity of the method. The most striking difference is between speech and the interval signal, and there was less tolerance for changes in the relative level of the interval signal than for other programme changes.

TABLE B

	Preferred change in level (db)
From speech to speech	0
From music to speech	−4 to −5
From speech to loud-starting music	+2
From speech to quiet-starting music	+2 to +3
From speech to interval signal ...	−10

TABLE A

Preferred Maximum Sound Level (db above 10^{-16} watts/cm²).

	Public		Musicians	Programme Engineers		Engineers
	Men	Women		Men	Women	
Symphonic Music	78	78	88	90	87	88
Light Music	75	74	79	89	84	84
Dance Music	75	73	79	89	83	84
Speech	71	71	74	84	77	80

* "Listeners' Sound-Level Preferences," by T. Somerville and S. F. Brownlees, *B.B.C. Quarterly*, Vol. 3, No. 4, and Vol. 5, No. 1.

UNBIASED | By FREE GRID

Exhibition Nightmare

IN 1951 the radio exhibition is due to make its debut at Earls Court and I do hope that the opportunity will be taken to arrange matters so that it is less tiring than hitherto, especially for the provincial visitor with limited time to spare.

To my mind the mistake in the past has been that manufacturers have exhibited all their goods on one stand. Thus, if you were in search of a first-class radiogram and wished to compare the efforts of one manufacturer with another, you had to go from stand to stand and elbow your way through a lot of plebeian clutter like table-top sets and portables to get at the radiograms. Having seen manufacturer A's radiograms you had to fight your way to the other end of the hall to compare them with manufacturer B's products.

I think, therefore, that we might borrow an idea from the 1950 Motor Show where all the makers of tyres were grouped together in splendid isolation. In this section they exhibited tyres only and showed their inflators and other wares on separate stands elsewhere in the show. I should not like it to be thought, however, that I am handing a bouquet to the motor industry at the expense of our own, for, except for this particularly striking instance of forethought and orderliness, the rest of the accessory stands seemed to me to be scattered in the same confusion as the Children of Israel in the prophet's famous vision. I learned of this confusion by bitter experience when searching for a good headlamp for the pram of Free Grid Minimus, the offspring of my daughter Faradia. She needs this when collecting him late at night from one of the crèches which some cinemas, as a counterblast to the stay-at-home attractions of television, now thoughtfully provide so that mothers can leave their infants to be washed and refuelled while they are enjoying the show.

Refuelling Service.

At Earls Court next Autumn, therefore, I hope to see radiograms all grouped together in one section, table-top sets in another and so on so that the choice between one maker's product and another's will be made easier. It will mean, of course, that some manufacturers will have to have half-a-dozen stands in different parts of the show, but what does that matter? Earls Court is quite big enough to contain them.

Who Invented It?

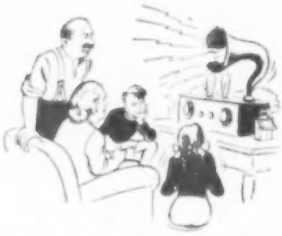
I SEE that an American journal has raised the old and rather pointless question of "who invented radar and when?" A lot depends on what we mean by radar. It may make it a bit easier if we call it radiolocation as we did originally. But even this does not really enable us to solve the problem for radiolocation obviously means the locating of things by radio, and if we take that definition I suppose we must hand the palm to Professor Röntgen and put the date at 1895 when the word "radio" had purely an X-ray association. "Röntgen Revealing Rays" as they were once called are most certainly used to find hidden objects, more especially by the medical profession, who, by their aid, find with great precision the exact location of Aunt Maria's Bevan-sent teeth when she accidentally swallows them.

However, most people when they talk of radiolocation have in mind the position-finding of aircraft and therefore they think of names like Watson Watt and the year 1935. But even so they are hopelessly out of date for the N.P.L., as far back as 1928, used radio waves to find the position of meteorological balloons which, being neither land, sea nor submarine craft, are undoubtedly aircraft.

The truth is, of course, that the pinning down of an invention to a man and a date is an almost impossible task.

Stereoella

IN his resignation statement a few months ago the erstwhile controller of television made it clear that in his opinion television is the Cinderella of the B.B.C. services.



Cacophonous infantile stage.

But nobody need shed any tears over that for it won't remain so for long whatever the panjandrums of Portland Place may decide. For all Cinderellas, following the example of the original creation, have a cuckoo-like habit of starting in a small and humble way and finally throwing all others out of the nest. Sound broadcasting itself, now grown as old and cantankerous as one of the ugly sisters, started life as a Cinderella not only in the entertainment world but in the radio world also.

In the entertainment world we heard in 1922 that broadcasting was just a passing novelty soon to be buried in the British Museum alongside the musical box and the zoetrope. In the radio world it was considered as just a clutterer-up of the ether which must not be tolerated and which would, in any case, never grow beyond the cacophonous infantile stage.

Way back in the late nineties and early nineteen hundreds radio itself was the butt of the cable companies in their none too gentle jesting; an upstart minx to be put in her proper place. But in due course the jokes ceased and we learned that a marriage had been arranged and would shortly take place, and a most fruitful marriage it has been, judging by the sturdy offspring which the State eventually took over from its proud parents. So, too, it will be with television which will, before long, rule the roost at Broadcasting House and another Cinderella will take its place. It looks as if this new Cinderella is likely to be called Stereoella unless a fairy godmother can be found to outwit the evil stepmotherly machinations of Mr. Bishop, the B.B.C.'s Chief Engineer, which, with bold *mein-kampf*-like candour, he made no bones about in his famous *De-Hertzian-Combwerendis* letter to the Editor of this journal (W.W., April, 1950).

LETTERS TO THE EDITOR

The Editor does not necessarily endorse the opinions expressed by his correspondents.

E.H.T. Circuit

I FEEL sure that students of the craft of pulse technique would welcome your comments on the e.h.t. supply circuit described on pp. 365-6 of the October issue.

The circuit is described as a "tripler," whereas all good "fly-back" engineers know this circuit as a "doubler," only V_3 and V_5 being active in the generally accepted role when the pulse is on.

V_4 can be substituted by a coupling resistor of a few megohms resistance with little change in performance when the pulse source is of low impedance.

With a ringing transformer source it is obviously necessary to use V_4 as then the damping due to such a coupling resistor is removed.

The question now arises: Does V_4 play an active role beyond its function as a one-way coupling resistor in view of the applied waveform?

If it does not then the design for 25-kV using a 9-kV pulse will be some 30% low in output voltage.

Reference is suggested to RCA Review, March 1950, or to RCA publication ST-545, p. 21.

R. POLLOCK.

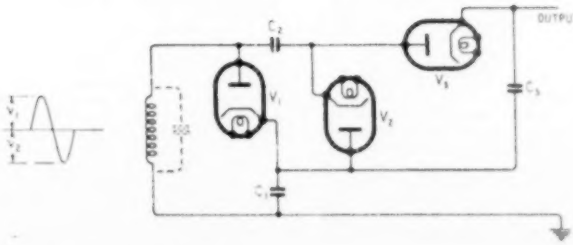
N. Wembley,
Middlesex.

Editorial Note.—Our correspondent is confusing the operating conditions of a voltage-multiplying rectifier system operating on a pulse input with those which exist with a sine-wave, or damped sine-wave, input. The so-called ringing-choke circuit produces a damped sine-wave and the three rectifiers do in fact act as a tripler and are all necessary.

Referring to the figure, on the first half-cycle of amplitude v_1, V_1 and V_3 conduct and on the second half-cycle of amplitude v_2, V_2 conducts. C_1 is charged to v_1 on the first half-cycle. On the second v_2 and the voltage across C_1 act in series to charge C_2 through V_2 and so C_2 is left charged to $v_1 + v_2$.

When V_3 conducts, on the first half-cycle, v_1 acts in series with the voltage across C_2 and the cathode of V_3 becomes $2v_1 + v_2$ above earth. If C_3 were returned to earth it would be charged to this voltage. It is, however, returned to C_2 and so is charged to $2v_1 + v_2$ minus the voltage across C_2, that is, to $v_1 + v_2$. The rating of C_3 can, therefore, be less than if it were returned to earth, but in each case the output voltage is $2v_1 + v_2$ and in with a high-Q circuit this is nearly $3v_1$, since $v_2 \approx v_1$.

If the input were a pulse, v_2 would be zero and the circuit would be a voltage-doubler only. V_2 could then be replaced by a resistor with slightly poorer regulation and efficiency.



Measuring Bass Resonance

RECENTLY I have been constructing a vented loudspeaker cabinet, and, having no beat frequency oscillator, was up against the problem of measuring the resonant frequency of my moving coil unit.

The problem was solved by using a bicycle fitted with a rear-wheel dynamo which is a simple form of alternator.

The procedure is to invert the bicycle and connect the loudspeaker to the dynamo with a protective resistance of suitable value in series. The pedals are then turned by hand until resonance is obtained. The detection of resonance is assisted by placing a small wood shaving on the diaphragm. The pedals are then rotated steadily at that speed and the number of revs. in half a minute

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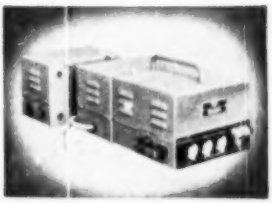

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counted (a watch with centre seconds hand is helpful). All that is necessary then is to count the number of revs. of the dynamo per rev. of the pedals. The revs./sec. of the dynamo gives the required frequency (since it has two poles).

The speaker I tested was a 10-inch, and initially a 100-Ω series resistor was used. The voltage generated at low speed is small, and after the resonance has been located the resistance can often be reduced or even omitted.

I made three tests:

(1) With 3-speed in "normal."

(2) With 3-speed in low gear.

(3) As in (2) but with a rubber band round the dynamo friction wheel.

The results in order were 71.5 c/s, 72 c/s and 72.8 c/s.

If the dynamo is properly set the question of slip does not arise and with a steady hand and careful timing consistent results should be obtained.

The waveform of such a dynamo is probably pretty shocking, but apart from simplicity and cheapness the method has the further advantage of being an "absolute measurement" and is not subject to calibration errors or zero wandering, etc.

A further use is to detect and measure frequencies of l.f. resonance in panels of a speaker cabinet.

I do not wish to claim to be the first to use the idea, but thought it might be useful for other readers who, like myself, cannot afford or obtain the use of expensive gear.

ANTHONY W. BOVILL.
London, N.2.

Valve Heaters

I HAVE read C. F. K. Gaulder's letter in your October issue with interest, and wonder whether the following might be of any interest.

Having been for many years very keen on "quality reproduction," and living in a country district with no access at that time to an a.c. supply, but having a 50-volt d.c. installation, I decided, about 15 years ago, that something must be done to overcome the difficulty. The result was that I built a superhet receiver with six 4-volt 1-amp. a.c. valves with the heaters in series. The output of this was fed into a paraphase push-pull a.f. amplifier with two more 4-volt valves and two special indirectly heated power valves giving 5 to 6 watts output. This gave me eight 4-volt heaters in series. A small regulating resistance plus a low-voltage gas-filled lamp acting as a barretter completed this heater circuit across the 50-volt supply. The power valves had 12-volt heaters also supplied by the 50 volts. The H.T. supply was provided by a small rotary converter.

Now, the point of all this is that with occasional trifling modifications and improvement, I have run this set for 15 years, and my valve renewals, apart from one or two new power valves, have been quite negligible. They have been tested periodically and their efficiency has remained remarkably high. I attribute this to two main causes:—(1) the heaters are switched on 20 to 30 seconds before h.t. and (2) when the convertor is switched on the h.t. voltage builds up from zero volts, producing no surge or shock.

There may be other causes, but the arrangement has certainly given good service.

JOHN OGILVY.
Forfar, Scotland.

The Coupling Capacitor

AS an addendum to "Cathode Ray's" article in the October issue, the attention of readers is directed to the basic relation:

1 amp into (or out of) 1 farad produces a change of 1 volt in 1 second.

For practical use this is conveniently converted to

1 mA : 1 μF : 1 volt : 1 millisecond.

Many smoothing and decoupling problems are easily solved, with sufficient accuracy, by the use of this simple relationship, which does not even demand a knowledge of the value of π.

As an example, consider a valve which is to be used as a pentode cathode follower. The screen current varies from 5 mA by ±5 mA, and the lower frequency is 50 c/s. What capacitance must be used to decouple screen to cathode?

A half-cycle lasts 10 millisec, so that we have

1 mA : 1 μF : 1 V : 1 millisec.
5 mA : 1 μF : 5 V : 1 millisec.
5 mA : 1 μF : 50 V : 10 millisec.

And finally, if the screen-cathode voltage is not to vary by more than ±5 volts:

5 mA : 10 μF : 5 V : 10 millisec.

The answer, of course, is then to use a 16-μF electrolytic, so that a more academic approach has no justification.

THOMAS RODDAM.

Television Visor

I RECENTLY noticed that there is a distinct improvement in my television picture when it is viewed through a small aperture held close to the eye. The effect consists in a useful increase of image contrast and of the detail perceived and, particularly with a foggy, unevenly lit picture, can be quite remarkable. It is equally evident with an aluminized as with a non-aluminized tube and is greatest when viewing in darkness or reduced room lighting. As I am reactionary enough to hold that this is still the best way to view a television picture, whatever the tube or the gadgets affixed to it, I find a "visor" constructed on the above principle to be a useful aid to maximum realism in viewing. It consists of an old pair of spectacles with black card substituted for the lenses and a pair of one-eighth inch holes punched the correct distance apart. This distance was found by preliminary trial with a piece of cardboard.

Should any reader try this out and confirm the effect I would be glad of suggestions as to an explanation. The effect of interposing the aperture is evidently to "stop down" the eye as with a camera lens; it seems that the iris mechanism of the eye may not fully adjust itself to the brightness of a scene when this subtends an angle as small as a television picture. Probably some defect of the eye prevents the full detail being perceived in these circumstances, there being a degradation due to flattening or halation. However, I find that the "visor" gives no improvement in a home cinema picture under any conditions. If the above suggestions have any weight this may be bound up with a difference of spectral content, or of the means of presentation of the picture. Regarding the former, I find personally that a noticeably bluish screen colour gives me a better impression of detail, other things being equal, than a warmer toned one.

E. G. HARRISON.
Sandiacre, Nottingham.

Circuit Diagrams

WHEN drawing circuit diagrams it is often difficult to cram in component values by the side of the appropriate symbol; things are made even worse if one wishes to draw attention to ratings, such as wattage, voltage-working or tolerance. So it has become usual to enumerate the various components and give ratings in a separate panel and/or discussion in the text. The disadvantage of this method is finding, say, "R_{14}" or "C_{31}" in a maze of circuitry. There seems to be no consistency in the method used to code the components, and I suggest as an alternative a division of the receiver, etc., into stages, or, where this is ambiguous, arbitrary divisions of the circuit by vertical dash-dot lines. The components could then be given a reference number first, to locate the section, and then an identifying number—e.g., R_{14} being a resistor in the 4th sec-

tion (working, say, from the left).

A further convention for numbering is needed when drawing the circuit, and the most obvious one seems to be marking the components in the order one would "read" down the section, i.e., left to right, moving downwards from H.T.+ to the zero-potential line.

M. BAMFORD.
Macclesfield, Cheshire.

Television Relay Loss?

DURING the televising of the current Radio Exhibition at Castle Bromwich it was noticed that the quality of picture was exceptionally good in this district.

The Exhibition programme came, of course, from Birmingham and hence the transmission was direct, viewers to London receiving it third-hand.

At the end of the item the programme was switched back to Alexandra Palace, and a decided lessening in quality of picture was noticed.

I am given to understand that there are two link transmitters for vision, making 3 "hops" in all (including the main service transmitter) and if the loss in quality is linear per link, one may wonder what the picture will be like from the proposed Scottish transmitter.

It would be interesting to know whether viewers to the London transmitter noticed a change in quality, to the better of course, at the above-mentioned change-over.

C. LAWSON.
Burnley, Lancs.

Educating the Public

I FULLY endorse your editorial comment on the lack of technical explanation and demonstrations at our National Radio Exhibitions.

It would appear that the radio industry does "face with complacency a situation where receivers are bought on eye appeal," even if that complacency is confined to the publicity department.

So long as radio receivers are dressed up as pieces of furniture "eye appeal" of the cabinet will have to be considered, but I see no reason why that should prevent the manufacturer from explaining the difference between his 18-guinea and 26-guinea models.

I have long advocated that the radio industry should go further than this, and that instead of plugging the old, old story of "Finest Value," "Greatest Performance," "Sweetest Tone," etc., regardless of price and specification, the industry should advise the public on the technical attainments and limitations of their various models and demonstrate that should a superior performance be desired it can be obtained in a higher-priced model.

H. WILLAN CRITCHLEY.
Scarborough, Yorks.

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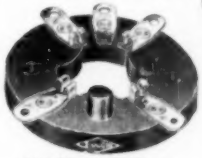

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By "DIALLIST"

Slow Warming Up

No-one could agree more whole-heartedly than I with those readers who lament over the length of time that modern mains valves take to warm up. Having realized all of a sudden that it is just about the moment for a time signal, or for some programme item that you specially want to hear, one switches on and waits with growing exasperation for what seems ages, although, in fact, the actual time taken for the set to come to life is only 30 or 40 seconds. C. F. K. Goulder's suggestion in the October *Wireless World* that we should leave heaters permanently switched on and merely cut out the h.t. has much to recommend it. A good deal of the radio and radar equipment in the Services was treated in that way during the war and no particularly dire effects on valve life were noticed. I am not sure, though, that I would be altogether happy about doing this with some kinds of pentodes. I suppose the ideal thing would be an arrangement allowing the h.t. to be run up smoothly from zero to full value in a second or two. Keeping the heaters switched on, by the way, is not nowadays a complete safeguard against switch-on surges. What about those all-too-frequent power cuts?

Overcrowded Wavelengths

Things are pretty bad just now on the medium-wave band. In one recent week there was for two days a poisonous high-pitched and rather wavery heterodyne affecting the London Regional transmission, whilst the National programme on three other wavelengths suffered from over-close neighbours. Part of the trouble is due to American Army broadcasting stations in Germany, but they are not the only ones to be guilty. There appears to be too much wavelength-wandering by stations which juggle with their carrier frequencies in efforts to avoid interference with their programmes. What we are going to do about it I don't know, for there doesn't seem much likelihood of getting agreement amongst all European countries to do the necessary tidying up. What is surprising is to find our own country, which is usually ready to do the right thing, permitting the Bovingdon Airport beacon to go on operating on 223 kc/s, which falls between the frequencies of Oslo and Warsaw, and so causing bother on the long-wave band.

A Fine Opportunity

There's a wonderful opportunity awaiting anyone who can devise a small, simple and inexpensive electronic calculating machine capable of dealing in the twinkling of an eye with the odd problems in addition, subtraction, multiplication and division with which so many of us have to cope daily. The first two are always laborious if large figures are concerned—and it's so easy to make footling mistakes. The slide-rule is a great help to multiplication, division and more intricate processes in which these are involved; but unless the slide-rule is a very elaborate affair and its users very skilled, the degree of accuracy is only about that of two-figure log. tables. Logarithms are fine—so long as you can put your hand on the book of tables when you want it. They are hardly worth while, though, if you are confronted with an isolated problem such as, say, 3572 × 2106 or $\sqrt{4126}$. It's quicker then to work out the answer. What a boon it would be if one had on one's desk a little instrument with a set of keys and switches which could be relied upon to give the right answer to such problems in a brace of shakes.

Battery Manufacturers' Please Note

The dry batteries, and particularly the H.T.Bs. that we get nowadays, aren't always as good as they should and could be. It's difficult, I know, to obtain first-grade materials except at prohibitive prices and that fact, no doubt, accounts for a good deal of trouble. Still, I don't think that the dry cell which comes to a premature end through the puncturing of its can should be seen quite so often as it is. For some reason, ascribable only to the perniciteness of fate, if one cell of a H.T.B. decides to blow up, the casualty almost invariably occurs somewhere in the middle of the battery. You read the e.m.f. of the battery under load one evening and find that it is something like 1.2 V per cell. Next day the set won't work and the H.T.B. has no e.m.f. worth talking about. If you care to investigate the innards of the battery, you can locate the faulty cell and short it out. But that may be a fiddling and rather messy business. It may be messier still and not without dire results if a punctured cell goes on oozing.

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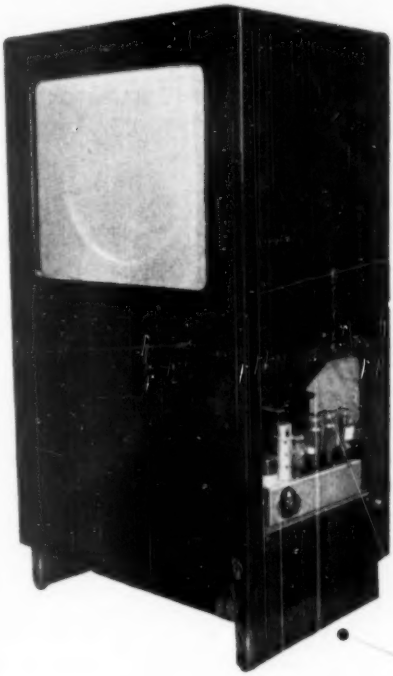

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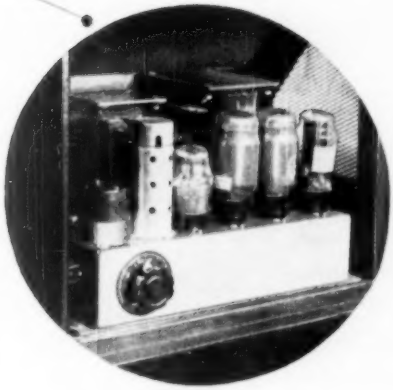

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CONSTRUCTOR'S PARCEL, comprising :—
Chassis 10½in.×5½in.×2in. with speaker and valve holder cut-outs, R. and A. 6½in. P.M. with transformer, twin gang with feet, pair medium and long wave iron cored T.R.F. coils. Four International Octal valve holders, wave-change switch and Erie 20k pot with switch, **25/-,** plus 1/6 post and packing.

CONSTRUCTOR'S PARCEL, comprising chassis 10½in.×5½in.×2in. with speaker and valve holder cut-outs; Rola 5in. P.M. with O.P. trans.; twin-gang with trimmers; pair of T.R.F. coils; Four international Octal valve holders; wave change switch and Erie 20k pot. with switch, **19/6,** plus 1/6 post and packing.

CONSTRUCTOR'S PARCEL, comprising Midget twin-gang with slow-motion drive; pair midget 465 Kc. I.F.s; frame aerial; medium wave osc. coil and layer type H.T. and L.T. batteries 90 v. + 1½ v., **21/-,** plus 2/- post and packing.

STANDARD 465 KC. I.F.s. Iron cored Q.120. 7/- per pair.

MINIATURE 465 KC. I.F.s. Type M4008. **12/6,** plus 6d. post and packing.

MINIATURE 465 KC. I.F.s (slightly larger than the above item). Q.120. Per pair **10/-.**

IRON CORED 465 KC. I.F.s. Q.130. 2½in.×1½in., per pair **6/-.**

IRON CORED 465 KC. WHISTLE FILTER, screened, each **2/-.**

VALVE HOLDERS. Paxolin International octal, **4d.** each. Moulded International octal, **6d.** each. EF50 ceramic **7d.** each. Moulded B7G slightly soiled **6d.** each.

LINE CORD. 3-way 0.3 amp., 180 ohm per yard. **11d.** per yard. 3-way 0.2 amp., 300 ohms per yard, **1/-.**

CERAMIC P.F.S. 3 each of the following: 330, 220 180 and 82, **2/6.**

VOLUME CONTROLS, by famous manufacturer. Long spindle and switch, ¼, ½, 1 and 2 meg., **3/6** each. 20, 25 and 50 k., **3/-** each. Post and packing 3d. each.

VOLUME CONTROLS, by famous manufacturer. Long spindle less switch, 5 k., 50 k., 500 k., 1 meg., **1/9** each. Post and packing 3d. each.

5-VALVE A.C. MAINS, 200-250 v., 3 wave-band superhet chassis. 1,000-2,000, 200-550 and 16-50 metres. By very good manufacturer, complete with valves, 6K8, 6K7, 6Q7, 6V6, and 5Z4. Size of chassis 11½in.×7½in.×2in. Size of glass scale 8½in.×7½in. with pick-up sockets (takes 8in. P.M. with trans.) TAX PAID. **£8 18 6.** Post and packing 2/6.

CONSTRUCTOR'S PARCEL, comprising: 5-valve superhet chassis with I.F. trans. and V.H. cut-outs, 13½in.×6in.×2in. with L.M.S. scale 7in.×5in., back plate and two supporting brackets. Drive drum, spindle and pointer, mains trans. G.E.C. 350-0-350 70 mA., 6 v. 2.5 amp., 5 v. 2 amp., and Plessey 8in. M. energised 2,000 ohm field with 5,000 ohm impedance, O.P. trans., **29/6.** Post and packing 2/-.

CONSTRUCTOR'S PARCEL, comprising: 5-valve superhet chassis with I.F. trans., and V.H. cut-outs, 13½in.×6in.×2in. with L.M.S. scale 7in.×5in., back plate and two supporting brackets. Drive drum, spindle and pointer, **6/6.** Post and packing 1/6.

CONSTRUCTOR'S PARCEL, comprising: twin gang with feet, pair long and medium iron cored T.R.F. coils, 4 octal V.H., 3 pole 2-way switch Erie 20k pot. w.s., heater trans. 220-240 v. 1 amp., 2 yds. flat silk flex, 3 black knobs, chassis 10½in.×5½in.×2in. with speaker and V.H. cut-outs, metal rectifier 60 mA., 230 v. and 12+12 mfd. 200 v., **19/6,** post paid.

GOVERNMENT SURPLUS. Removed from equipment but guaranteed:
Metal Rectifier, 230 v. 60 mA. **4/-.**
Metal Rectifier, 230 v. 80 mA., **5/-.**
Post and packing on each, 6d.
8 mfd. metal cased, 450 v. work, with clip, **1/-** each.

Stamp for List.

MAINS DROPPERS

2 amp. 1,000 ohms, tapped 900 ohms. **1/9.**

2 amp. 717 ohms, tapped 100 ohms. **1/6.**

.3 amp. 520 ohms, tapped 2/6 each.

WAVE CHANGE SWITCHES

3-pole 2-way, **1/2.**

4-pole 4-way, and 4-pole 3-way **1/9.**

1-pole 12-way, **2/6.**

3-pole 12-way, **4/6.**

5-pole 2-way midget, **1/9.**

Post and packing 3d. each.

TELEVISION MASKS

White Rubber. 9in. with glass, **10/6.**

White Rubber. 12in. with glass, **15/-,** plus 1/- post and packing.

DUE TO A LARGE PURCHASE OF MANUFACTURERS' SURPLUS
WE ARE ABLE TO OFFER THE FOLLOWING :—

Heater transformer fully interleaved and impregnated and guaranteed. 6.3 v. 1 amp., max. input 220/240 volts, **3/6,** post paid.

THIS MONTH'S OUTSTANDING OFFER

CONSTRUCTOR'S PARCEL, comprising chassis with V.H. and transformer cut-out, size 13½in.x6in.x2in. with scale size 7in.x5in. Back plate, two supporting brackets, drive drum, pointer and spindle. Mains transformer input 200-250 v. H.T. 280 v. 4 v. 3 amp. and 3 valves, 2 Octal H.F. pentodes, and 1 output valve, all ex-Govt.

£1 18s. 0d. *Post paid.*

POST ORDERS ONLY

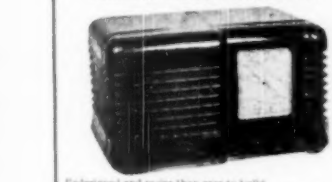
67 RALEIGH AVENUE, HAYES, MIDDLESEX

PREMIER RADIO COMPANY

MORRIS & CO. (RADIO) LTD.

A SELECTION OF PREMIER KITS

PREMIER MIDGET RADIO KIT

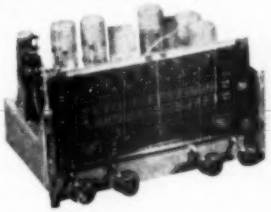


Redesigned and easier than ever to build.
Includes an attractive walnut or cream plastic cabinet 13in. × 8in. × 6in.
The valve line-up is 6K7, 6SH7 and beam power output (CV1510) in the A.C. model and 6K7, 6SH7 and 1LA6 in the A.C./D.C. model. Both use metal rectifiers and are for use on 200-250 volt mains. The dial is illuminated and the receiver presents an attractive appearance. Medium and long waveband coverage. Complete kit of parts with valves, speaker, cabinet and point-to-point diagram. Please state if A.C. or A.C./D.C. **£4 . 19 . 6** Inc. P.T.

NEW 3-BAND MIDGET SUPERHET KIT. Redesigned to cover the short, medium and long wavebands (16-50, 190-540, 1,000-2,000 metres). A.C. valve line-up, 6K8, 6K7, 6Q7, CV1510. Beam power output. A.C./D.C. valve line-up is the same excepting output valve is 1LA6. Both use metal rectifiers and are for use on 200-250 v. mains.
In cream or walnut cabinet as illustrated. Illuminated dial. An attractive and powerful receiver.
Complete kit of parts with Valves, Speaker, Cabinet and point-to-point diagram.
Please state if A.C. or A.C./D.C. is required. **£6 . 19 . 6** Inc. P.T.

NEW A.C. ALL-WAVE SUPERHET KIT.

7 valves (plus rectifiers) for 200-250 v., 40-60 cycle A.C. mains.
4 Wavebands, 13.5-32, 31-190, 190-540 and 900-2,100 metres.
Pick-up input. Uses 6K7, 6K8, 6K7, 6H6, 6J5 and 2-6V6 in push-pull, giving an output of 10 watts.
Specially designed OP transformer to match 3Ω's to 3 and 15-ohm speakers.
Negative feedback is applied over 2 stages giving a high fidelity output. Tone control is incorporated. **£14 5 -.**
Also available for A.C./D.C. Mains. Specification as above except that valve line-up is 6K7, 6K8, 6K7, 6Q7, 6J7, 2-KT36. In kit form at **£13 8 10**



GRAMOPHONE AMPLIFIER KIT.

Consists of Complete Kit of Parts for a 3½ watt, Mains-operated, 2-stage Amplifier for use with any type of pick-up. Volume and tone controls are incorporated. Output impedance is 3 ohms.
Cat. No. AMP147. Price complete, 65 -. For 200-250 v. mains with valves and diagrams.

WILLIAMSON AMPLIFIER KIT

We can supply the Kit of Parts for the latest version of this famous amplifier **complete in every detail** for **£10 10 -**, with Valves, output and mains transformers.
WILLIAMSON AMPLIFIER OUTPUT TRANSFORMERS to specification, 63 -.
Mains Transformers, 45 -.

H.T. ELIMINATOR AND TRICKLE CHARGER KIT.

All parts to construct an eliminator to give an output of 150 volts at 30 mA. and 2 volts to charge an accumulator. Uses metal rectifier. 35 -.

MAINS NOISE ELIMINATOR KIT.

Two specially designed chokes with three smoothing condensers with circuit diagram. Cuts out all mains noise. Can be assembled inside existing receiver. 6 - complete.

METER KIT.

A FERRANTI 500 MICROAMP M/C METER, with separate High Stability, High Accuracy, Resistors to measure, 15, 60, 150 and 600 volts D.C. Scale length 1¾in. diameter 2¼in., 10 - complete kit.

FURTHER EXPANSION!

ALL POST ORDERS SHOULD NOW BE SENT TO OUR NEW HEAD OFFICE AT 740 HIGH RD., TOTTENHAM, N.17.

Telephone: TOTTENHAM 5371.

WELDING OR GROUND HEATING TRANSFORMERS. Input 230 v. Output 15 v. 60 A. Tapped at 14-13.5-13 volts. 7½ × 7 × 6in. Weight approx. 50 lbs. Price **55/-.** Carriage and packing 15/-.

MOVING COIL LOUDSPEAKERS (3Ω v.c.).
3½in. Personal Type (15Ω v.c.), 15/-; 3½in. J.P., 9/-; 5in. Truevox, 10/-; 5in. Rola, 12/6; 6½in. Truevox, 12/6; 8in. Plessey, 14/6; 10in. Rola, 23/6; 12in. Truevox, 39/6. 8in. Truevox in handsome plastic cabinet (cream or walnut), 6 × 6in. with v. control, 27/6.

E.H.T. TRANSFORMER. Output 1,000 v. at 1 mA. with two 4 v. 1.5 A. LT's. In power supply this will give an output of 1,500 v. halfwave or 3,000 v. Fullwave. Price 17/6.

T.V. WHITE RUBBER MASKS.
We can now supply a specially designed White Rubber Mask for 9in. C.R. Tubes at 7/6 each.
9in. White Masks, 9/6. 12in. White Masks 16/11.

SUPER QUALITY TELEVISION MAGNIFYING LENS. To suit 3in., 5in., or 7in. Tubes. Increase picture size considerably. 25/- each.

PERMANENT MAGNET FOCUS POTS. Available for all Tubes, 15/-. Please state Tube used.

MOVING COIL METERS. All 2½in. outside diameter. 1 mA., 7/6; 5 mA., 5/-; 50 mA., 8/6; 100 mA., 6/-; 90 amp., 7/6; 40 amp., 7/6; 20 v., 5/9; 40 v., 5/9; 500 microamps, 7/6; All 3½in. outside diameter. 1 mA. 15/11; 30 mA., 10/6; 300 mA., 8/6; 500 microamps, 19/6; Thermocouple meters, 3½in., 2.5 amp., 5/-; 3 amp., 5/-; 3.5 amp., 5/-; 3½in. 2 amp., 8/6; Electrostatic 3½in. 2 kV., 25/-. 100v.DK. 4½in., 50/-.

SPECIAL OFFER OF ADMIRALTY REFLEX-RE-ENTRANT P.A. LOUDSPEAKERS, v.coil 7Ω. Matching transformers 4.5-1 and 6-1. Radius with vol.control at max. Very sensitive and directional. Single unit, 55/-. Twin units, 75/-. Carriage and packing, 5/-.

3½in. **GOODMANS M.C. P.M. LOUDSPEAKER.** Mounted in a cast aluminium case, 6¼ × 4 × 3in. with grille. 15Ω v.coil. Transformer ratio 17 : 1. 15Ω to 4,500Ω. With 100Ω v.v. vol.control 15/- each, plus 2/- carriage and packing.

SPECIAL OFFER OF COLLARO ELECTRIC GRAMOPHONE UNITS. The Motor, Tonearm and Crystal Pick-up in one unit with automatic stop and start. Induction motor, variable speed. For A.C. only, 100-250 volts, 50 cycles. List price £11 2/2. Limited quantity only at **£4 19 6**, plus 2/6 carriage and packing.

TRANSMITTER AND SPECIAL PURPOSE VALVES

805A	10 -	801B	10 -	203A	10 -
807	10 -	845	5 -	211/1	7 6
866	5 -	1625	5 -	213/4	7 6
872A	10 -	711A	6 6	VR65	7 6
866B	10 -	XH1.5	6 6	GU17/40	6 6
878	10 -	807	6 6	DET8	10 -
861	20 -	4C27	10 -	207A	10 -
832	10 -	1X2	2 6	227A	15 -
829B	10 -	9002	3 6	956A	2 6
803	10 -	9003	3 6	956	3 6
715A	10 -	9004	3 6	CV1810	6 6
1616	5 -				

RHT1(CV18)	20 -	MR500B(CV1508)	15 -
VR56(CV1068)	6 6	U19(CV187)	6 6
EL200(CV18)	40 -	N63(CV1199)	5 -
VT100(CV1336)	7 6	CV811(Kingstron)	5 -
U17(CV1119)	5 -	GU50(CV1072)	7 6
PT2B(BC(CV1046)	5 -	1626(CV1158)	3 6
VU111A(CV34)	6 6	6L6G(CV1102)	6 6
ADB(CV1314)	6 6	GU11(CV1202)	6 6
DQ(BC(CV1141)	6 6	V1966(CV29)	6 6
TT11A(CV3504)	6 6	E1148(CV76)	40 -
RL18(CV1137)	5 -	931A	30 -
HY114B(CV1303)	6 6	Base for 931A	2 6

100 mA METERS. 2½in. O.D. Flush mounting. Scale length 2½in. Internal resistance 430Ω. **35/- each.**

MIDGET 2-GANG CONDENSERS. 2¼ × 1¼ × 1¾in. For personal portables, 7/6 each.

152-153, FLEET STREET, E.C.4. *Phone: CENtral 2833*—**and at—207, EDGWARE RD., W.2.** *Phone: AMBassador 4033*

207, Edgware Road is open until 6 p.m. on Saturdays. Terms of Business: Cash with order or C.O.D. over £1

OUR CATALOGUE PRICE 6d. CONTAINS ALL THE NEWEST RADIO EQUIPMENT.

PREMIER RADIO COMPANY

MORRIS & CO. (RADIO) LTD.

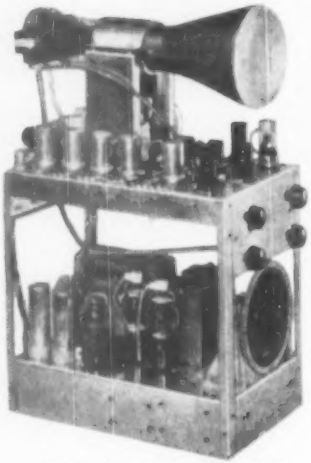
LONG RANGE TELEVISOR KITS

FOR THE LONDON OR BIRMINGHAM FREQUENCIES

£17 - 17 - 0

As is usual in Premier Kits every single item down to the last Bolt and Nut is supplied. All chassis are punched and layout diagrams and theoretical circuits are included.

FIVE EASY-TO-ASSEMBLE KITS ARE SUPPLIED :—



A well-made walnut finish **PEDESTAL CABINET** is available from stock at £5/10/0, plus 7/6 carriage and packing.

Working models can be seen during transmitting hours at our Fleet Street and Edgware Road branches.

VISION RECEIVER with valves, carriage 2/6	£3 13 6
SOUND RECEIVER with valves, carriage 2/6	£2 14 6
TIME BASE with valves, carriage 2/6	£2 7 6
POWER SUPPLY UNIT with valves, carriage 5/-	£6 3 0
TUBE ASSEMBLY, carriage and packing 2/6	£2 18 6

This unit includes the VCR97 Tube, Tube Fittings and Socket and a 6in. P.M. Moving Coil Speaker with closed field for Television. The instruction book costs 2/6, but is credited if a Kit for the complete Televisor is purchased.

Any of these Kits may be purchased separately ; in fact, any single part can be supplied. A complete priced list of all parts will be found in the instruction book.

20 Valves are used, the coils are all wound and every part is tested. All you need to build a complete Television Receiver is a screwdriver, a pair of pliers, a soldering iron and the ability to read a theoretical diagram.

The following sensitivity figures prove that the Premier Televisor Kit is capable of reception at greater distances than any other standard commercial kit or receiver whether T.R.F. or Superhet.

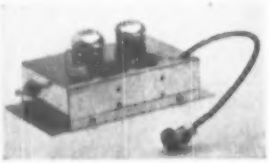
VISION RECEIVER.

Sensitivity	25μV. for 15V. peak to peak measured at the Anode of the Video Valve.
Sound Rejection	Better than 40 db.
Adjacent Sound Rejection	Midland Model. Better than 50 db.

SOUND RECEIVER.

Sensitivity	20μV. Vision Rejection, better than 50 db.

NEW PRE-AMPLIFIER FOR FRINGE RECEPTION AREAS



We can supply the complete kit of parts to make this wide band width Pre-Amplifier using 2-717A Pentodes. For use with Televisors able to supply 130v. 20 mA., H.T. and 6·3v., ·3 amps. L.T.

Completely screened. Includes valves, chassis, diagrams, etc. **27/6**

SEPARATE POWER SUPPLY UNIT KIT IF REQUIRED. 21/-

When ordering Televisor or Pre-Amplifier Kits

PLEASE STATE IF THE LONDON OR BIRMINGHAM MODEL IS REQUIRED

BRANCHES

207, EDGWARE RD., W.2 Phone : AMBassador 4033 (Open till 6 p.m. Saturdays)

AND AT **152-153, FLEET STREET, E.C.4** Phone : CENtral 2833

Terms of Business : Cash with order or C.O.D. over £1. Send 6d. Stamp for list.

ALL POST ORDERS to our new Head Office : 740 HIGH ROAD, TOTTENHAM, N.17. Phone : TOTtenham 5371.

PREMIER RADIO COMPANY

MORRIS & CO. (RADIO) LTD.

PREMIER TELEVISOR KITS

FOR LONDON AND BIRMINGHAM

USING 9" OR 12" MAGNETIC C.R. TUBES

£19·19·0 *including all parts, valves and loud-speaker, but excluding C.R. TUBE*

(Carriage and Packing 15/-)

CIRCUIT DETAILS

The Vision Receiver consists of 4 R.F. stages (EF54's) which are followed by a Diode Detector and Noise Limiter (6H6) which is directly coupled to the Video valve (EF54).
Complete Kit with valves, **£3 16 0.**
Carriage and packing 2/6.

The Sound Receiver comprises 3 R.F. stages (6SH7's) follwed by a Double Diode Triode (6Q7), which acts as Detector and L.F. Amplifier. A Noise Limiter (EA50) is also incorporated. The output valve (6V6) drives a 10in. P.M. Moving Coil Speaker with closed field magnet, which is included in the time Base Kit.
Complete Kit with valves, **£3 1 0.**
Carriage and packing 2/6.

The Time Bases employ blocking oscillators on both Line (6SH7 and 807), and Frame (VR137 and 6V6). E.H.T. (Non-lethal) is taken from the Line Output Transformer through a voltage doubler employing two valves (VU111). The Sync separators are 6H6 and 6V6.
Permanent Magnet Focusing.
Complete Kit with valves, **£8 5 6.**
Carriage and packing 5/-.

The Power Supply is from a double-wound mains transformer completely isolating the receiver from the mains. The H.T. Rectifier is a 5U4G.
Complete Kit with valves, **£4 16 6.**
Carriage and packing 5/-.

Walnut Finished Pedestal Cabinets from Stock for
9in. Tubes £6 15 0
12in. Tubes £8 8 0
Carriage and Packing 7s. 6d.

"MAGNETIC" CONSTRUCTION BOOK
3/-

Those living within range of the proposed new Northern T.V. Transmitters can commence building a Televisor for the Birmingham frequency.

As soon as the new frequencies are announced we shall be able to offer conversion details. This will entail coil alteration only.

The cost will be negligible. Alternatively we can supply Kits, less coils, and coils will follow as soon as the frequencies are announced.

EACH KIT OR INDIVIDUAL PART AVAILABLE SEPARATELY

The following sensitivity figures prove that the Premier Televisor Kit is capable of reception at greater distances than any other standard commercial kit or receiver whether T.R.F. or Superhet.

VISION RECEIVER

Sensitivity : 25 μV for 15V peak to peak measured at the Anode of the Video Valve.
Sound Rejection : Better than 40 db.
Adjacent Sound Rejection : Midland Model. Better than 50 db.

SOUND RECEIVER

Sensitivity : 20μV. Vision Rejection : Better than 50 db.

AT

207, EDGWARE RD., W.2 Phone : AMBassador 4033 (Open till 6 p.m. Saturdays)

AND AT **152-153, FLEET STREET, E.C.4** Phone: CENtral 2833

Terms of Business : Cash with order or C.O.D. over £1. Send 6d. Stamp for list.

ALL POST ORDERS to our new Head Office : 740 HIGH ROAD, TOTTENHAM, N.17. Phone : TOTtenham 5371.

ELPREQ SPECIALS

ELECTROLYTICS

	s.	d.
2 mfd. 450 v.	1	4
4 mfd. 450 v.	1	6
8 mfd. 150 v.	1	3
8 mfd. 350 v.	1	6
8 mfd. 450 v.	1	11
8 mfd. 500 v.	2	6
16 mfd. 150 v.	1	11
16 mfd. 450 v.	2	8
16 mfd. 500 v.	3	6
32 mfd. 350 v.	2	8
32 mfd. 450 v.	3	6
10 mfd. 25 v.		10
25 mfd. 25 v.	1	0
50 mfd. 12 v.		10
8 mfd. × 8 mfd. at 450 v.	3	4
8 mfd. × 16 mfd. at 350 v.	2	6
8 mfd. × 16 mfd. at 450 v.	3	6
16 mfd. × 16 mfd. at 350 v.	3	0
16 mfd. × 16 mfd. at 450 v.	3	9
16 mfd. × 8 mfd. × 24 mfd. at 450 v.	4	2
25 mfd. × 25 mfd. at 200 v.	3	11
16 mfd. × 8 mfd. at 350 v.	2	6
16 mfd. × 8 mfd. at 500 v.	4	6
250 mfd. at 12 v.	2	3
16 mfd. × 32 mfd. at 350 v.	3	4
12 mfd. at 50 v.	1	3

SHEET PAXOLIN

Invaluable for when you are experimenting. Size 6in. × 6in., 1/-. Size 12in. × 8in., 2/-. Size 12in. × 12in. 3/6, size 24in. × 12in. 6/-. Average thickness 1/16in.

B.A. SOCKET SPANNERS

Covering sizes 0-6 B.A. and with double ended wrench as illustrated. A really good set which will help you with those nuts in awkward corners, price 5/6 complete.

POLISHED B.A. SPANNERS

Covering sizes 1 to 6 B.A., these are so made to have a straight and a right angle end for each B.A. size. 6/- set.

QUADRANT-TYPE SCRIBERS

For marking out chassis these are the ideal tool, normal price 7/6, our price while they last, 3/9.

PUSH-BUTTON SWITCH UNIT

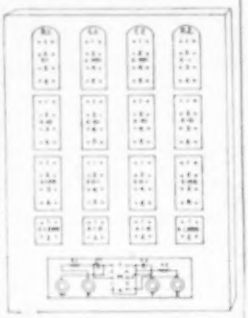
For three waveband and mains on/off complete with knobs. 1/6.

EGG INSULATORS.

For all sorts of aerials including T.V. 1¾ long × 1 × 1. 4d. each. 3/6 doz.

EQUIP YOUR LABORATORY

You many times have felt the need of a device which would enable you to put resistance or capacity or a combination of these two quickly into a circuit. We have a small quantity of resistance capacity boxes which, by the simple manipulation of plugs, will enable you to do this. With these boxes you can put in 1 ohm, 2 ohms, 3 ohms, 4 ohms, and so on, in steps of 1 ohm, right up to 6,000 ohms. In a similar way capacity can be put into circuit by small amounts, thus making it simple for you to find optimum working conditions. These boxes made for Government Laboratories are available while they last at 19/6 each, plus 1/6 post and packing. Don't delay—order by return.



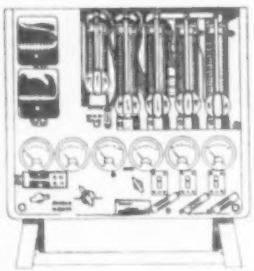
POWER PACK TYPE 392

This is an extremely useful unit which works off A.C. without modification giving an output of 700 v. D.C. adequately smoothed. Here is a list of the components contained in the power unit: Mains Transformer for 200-250 v. 50 cycle, with secondaries of 700-0-700 v. at 70 mA., 4 v. at 2.5 amps., 12.5 v. at 1 amp. (Note these are Admiralty ratings, the transformers will stand at least twice these figures). Also two rectifier valves type CV54, 10-watt resistors, three 4 mfd. 100 v. condensers, L.F. choke, 10 henry 100 mA., 2 slydlok fuses. The power pack is unused and is contained in a louvred case size 12in. × 8½in. × 8½in. Price 67/6.

"SNIPERSCOPE"

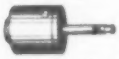
Famous wartime "cats eye" used in conjunction with a lens system and h.t. for seeing in the dark. This is an infra-red image converter cell with a silver caesium screen which lights up (like a cathode ray tube) when the electrons released by the infra-red strike it. It follows that as light from an ordinary lamp is rich in infra-red these cells will work: burglar alarms, counting circuits, smoke detectors and the hundred and one other devices as will the simpler type of photo cell. Here then is a golden opportunity for some interesting experiments price 9/6 each, or six for 52/6. Data will be supplied with cells if requested.

CHARGING SWITCHBOARD



This contains five high-wattage slider type variable resistors, four flush meters reading up to 15 amps each, and one reading up to 40 amps. In addition there is a voltmeter with a selector switch to permit voltage checking of all circuits, two cut-outs, switches, fuses and terminals. The whole being mounted on a panel and enclosed in a metal case with doors and feet. A source of D.C. fed in will be split up to permit battery charging at varying currents. If used with a generator the field of same and hence its voltage output can be controlled by the first slider. Excellent break-down value, as any one of the sliders would cost much more than we ask for the whole unit. Price 57/6, carriage 12/6.

TELEPHONE JACK PLUGS



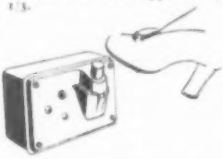
As illustrated 7d. each, sockets to suit, 10d. each.

METAL RECTIFIERS

Selenium 250 v. 100 ma., 4/3.

5-WAY PORCELAIN CONNECTOR BLOCKS

Hundreds of useful applications, 1/3.



15 amp. shuttered switch plug, bakelite moulded surface, mounting type, made by very famous maker, made to B.S.S. 7/6 each.

P.M. SPEAKERS

All speakers are by very famous makers such as Rola, Celestion, Goodmans, etc.

Size	With Trans. s.	d.	Less Trans. s.	d.
2½in.	—		10	6
3½in.	—		10	0
5in.	12	3	10	6
6½in.	12	6	10	6
8in.	13	6	11	6
10in.	18	6	16	6
12in.	—		39	6

I.F. TRANSFORMERS

465 kc/s, iron dust cored very high "Q" fitted in standard size can, 6/9 per pair, 465 kc/s iron dust cored very high "Q" fitted in midget size can, 12/6 per pair. 465 kc/s air cored, medium size can, 6/9 per pair.

L.F. CHOKES

Heavy duty types suitable for power packs and mains smoothing. These are mostly Government Surplus.

	s.	d.
200 mA. 10 henry	10	0
200 mA. 3 henry	5	0
Midget-type inductance unknown	3	6
120 mA. 9 henry	6	6
80 mA. 10 henry	4	6
80 mA. 5 henry	4	0
40 mA. 5 henry	3	6

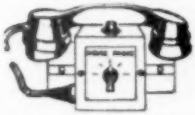
OUTPUT TRANSFORMERS

Midget pentode matching to 3-5 ohms	3	6
Standard pentode matching to 3-5 ohms	3	9
Medium pentode matching to 3-5 ohms	3	3
Standard size multi-ratio	4	6

VOLUME CONTROLS

All have full-length spindle and are complete with fixing nuts. We stock full range of values between 2,000 ohms and 2 megohms, prices are less switch, 2/6 each; single-pole switch 3/9 each.

HOUSE TELEPHONES



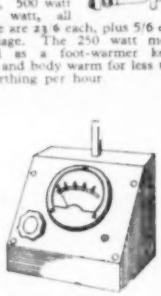
Desk or Wall Mounting

Suitable for intercommunication between offices, workshops, stores, garages, big houses, kitchens, etc. Each station consists of normal size Bakelite handsets and desk or wall mounting cabinet with built-in selector switch, buzzer and push. All stations can communicate with one another independently. Each installation is absolutely complete and internally wired. 3-station installation complete with 50 yards 5-core cable £6/10/-. 4-station installation, complete with 50 yards 6-core cable, £8/10/-. 2-station installation, complete with 25 yards 4-core cable, £3/17/6.

ELECTRIC HEATERS

Heavy cast framework totally encloses the elements, so these are 100% safe even in confined spaces, just right for your radio den, garage, office, shop, etc. 750 watt (heavy) model, 23/6, plus 5/6 carriage. Other models available: 750 watt, 500 watt £50 watt, all these are 23/6 each, plus 5/6 each carriage. The 250 watt model used as a foot-warmer keeps legs and body warm for less than a farthing per hour.

SHORT TURNS COIL TESTER



You know that it is almost an impossibility to test for shorted turns in I.F. Transformers, Coils, L.T. Transformers, etc., with an ordinary ohmmeter. Our mains-operated shorted turns coil tester will reveal these faults in a second. An essential instrument in all coil-winding shops as it will test for continuity at the same speed. £6/10/-.

LIQUIDATOR'S STOCK

Polished walnut radio cabinet size 20 × 12 × 7½in. complete with L., M. and S. dial, size 7 × 6½in. and backplate with magic eye cutout, also with drilled chassis and hardboard back. You will find it quite a simple matter to complete this into a very handsome receiver of the £15 class. Limited quantity, price 32/6, plus 2/6 carriage for the 5 items.

PLUG AND SOCKET

This brass cased plug and socket is extremely robust and ideal for P.A. or outside work. Ideal also for taking power to units as it insulates the ends of the wires. Contacts are quite suitable for carrying up to 10 amps. so this can be used for lighting or power. Price 2/6 per pair.

TWO SUPER SPEAKERS

The first is a beautifully made 10in P.M. speaker, a real precision product made by a very famous speaker firm. It is undoubtedly a 10in. which reproduces with all the quality of a 12in. It has three special features (1) a solid diecast frame (2) a special 'speech' coil suspension which gives wider frequency response (3) dustproof cone assembly. Speech coil is normal 2/3 ohms. Price is 16/6 plus 2/6 post and insurance. The second is the 8in. P.M. speaker made by the same firm whose name incidentally we are not allowed to mention but you will recognise it immediately. This again has normal 2/3 ohms coil. Price is 11/6 plus 1/9 post and insurance.

BREAK-DOWN UNIT

At present day prices the spares in this unit would cost at least £5. Here is a list of the main contents: 3 two-metre coils; 3 tuning condensers, split-stator type; 4 two-watt carbon resistors, useful values; 1 tapped 20 watt resistor, vitreous covered; 6 paper condensers, .05 mf. 1,000 v. working; 3 paper condensers, .1 mf. 1,000 v. working; 2 H.F. chokes; 4 paper condensers, .1 mf. 450 v. working; 2 paper condensers, .15 mf.; 5 bakelite moulded mica condensers .001; 1 paper condenser, .01 mf. 3,000 v. working; 24 rubber grommets, assorted sizes; 6 resistors 1 watt, all useful values; 6 resistors ½ watt, all useful values; 40 resistors ¼ watt, all useful values; 40 silver mica condensers assorted values, including 10, 15, 20, 40, 50, 100, 150, 800, and 500 pf. types; 4 English octal valve holders; 2 English 5-pin valve holders; 1 E.F.50 type valve holder; 3 diode valve holders; 1 louvred casing, size 12 × 7 × 4in.; 1 heavy metal chassis size 12 × 7 × 2in.; 8 condenser clips, assorted sizes. Also an assortment of nuts, bolts P.K., self-threading screws, tag boards, chassis mounting tag connectors, screened grid caps, plain grid caps, levers, rollers, connecting rods, output sockets, etc., etc. ALL THIS COLLECTION OF PARTS FOR 6/6 only, plus 1/9 postage and packing.

THIS MONTH'S SNIP

TIMED SWITCH MECHANISM. This comprises a beautifully made 8 day jewelled miniature clock or watch movement, which operates two 2 amp contact switches. These switches also are quite suitable for mains use. There are two calibrated dials, one contact adjusts in ½ hour intervals up to 6 hours, the other one in one hour intervals up to 36 hours. The whole is really precision made to stringent M.O.S. specification. The size of the complete switch mechanism is 3in. long and 2½in. across. Or if you wish the miniature clock movement can be removed completely and this then measures only 1½in. × 5in. The price of the complete timed switch is 27/6. These are brand new still in the manufacturers original sealed boxes.

MAINS TRANSFORMERS

Ordinary—E.H.T.—Special.

All transformers are suitable for 200-250 v. 50 cycle mains, are fitted with primary screens, fully impregnated and complete with all necessary clamps, etc.

300-0-300 at 80 mA. 6.3 v. at 4 amps. 5 v. at 3 amps. Half shrouded drop through, **14/6.**

260-0-260 at 60 mA. 6.3 v. at 3 amps. 5v. at 2 amps. Half shrouded drop through. Price **13/9.**

350-0-350 at 80 mA., 4 v. at 6 amps. 4 v. at 3 amps., drop through or upright mounting, a useful replacement type for old-type receivers, **16/6.**

350-0-350 at 100 mA., 6.3 v. at 5 amps., 5 v. at 2 amps. Fully shrouded upright mounting, **19/6.**

250-0-250 at 60 mA. 4 v. at 4 amps. 4 v. at 3 amps. Half shrouded drop through. Price **11/9.**

235-0-235 at 60mA. 6.3 v. at 3 amps., 5 v. at 2 amps. Fully shrouded upright mounting, **15/-.** Primary has an additional tap for 110 v.

Filament Transformer, 6.3 v. 1½-2 amps., upright, **6/-.**

350-0-350 at 160 mA., 5 v. at 3 amps., 6.3 v. at 6 amps., 6.3 v. at 3 amps. Fully shrouded upright mounting, **36/-.**

250-0-250 at 100 mA., 5 v. at 3 amps., 6.3 v. at 6 amps., **27/6.**

2,500 v. at 5 mA., 4 v. at 1.5 amps., 202 v. at 2 amps., **25/-.**

4 KV. at 5 mA., 2 v. at 2 amps., potted with insulators, **67/6.**

Special combined transformer designed to be suitable for Televisor or oscilloscope using a 6in. tube VCR97, etc. 400-0-400 at 150 mA., 2.5 KV. at 5 mA., 6.3 v. at 6 amps., 6.3 v. at 6 amps., 4 v. at 1 amp., 4 v. at 2 amps., 5 v. at 3 amps., **70/-.**

SPECIAL

MAINS AUTO TRANSFORMER

6.3 v. at 2 amps., 60 v. at 200 mA., tapped 200/220, 230/250, **7/6**

Orders under **£2** add 1/6, under **£1** add 1/-. Postable items can be sent C.O.D., additional charge approx. 1/- Good stock of all items at time of going to press. List 6d. **Telephone: Ruislip 5780**

ELECTRONIC

PRECISION EQUIPMENT (2) ELECTRON HOUSE, Windmill Hill, RUISLIP MANOR, MIDDX.

CLYDESDALE

Bargains in Ex-Service Radio and Electronic Equipment

FOR THE TELEVISION CONSTRUCTOR

FOR VIEWING

INDICATOR UNIT TYPE 62. Contains a VCR97 Cathode Ray Tube with a mu-metal shield plus a host of other components suitable for the TV constructor and the following valves make suitable spares for the R1355:
16:SP61's, 2:EB34's, and 2:EA50's.
The complete unit is housed in a metal retainer 18in. x 8½in. x 11½in.

CLYDESDALE'S PRICE ONLY 67/6 each POST PAID

Circuits available at 1/3 each.

100% COMPONENT VALUE

R.3515 I.F. A.F. AMPLIFIER UNIT comprises numerous components which will be suitable for the TV constructor—plus a 6 stage 12.25 Mc/s. IF strip mounted on a detachable sub-chassis. The R.3515 provides relays, condensers, potentiometers and resistors. 10:SP61, 5:EF36, 3:EBC33, 1:EB34, 1:EF39 and 1:EA50 valves. It's too good to miss. Totally enclosed in a metal retainer 18in. x 11½in. x 7½in.

CLYDESDALE'S PRICE ONLY 67/6 each POST PAID

VIEWING TUBES

3in. ELECTROSTATIC 3PB1 (E779). This Tube is a compact unit extremely suitable for test work or for small portable equipment where only a 1,000 to 2,000 volt is available. Filament supply required 6 v. The base is diphetal. Brand new in maker's cartons and carefully packed before shipment.

CLYDESDALE'S PRICE ONLY 22/6 each POST PAID

6in. ELECTROSTATIC VCR97 (E351). This tube is very popular with Television constructors and has been universally used. The VCR97 is a short persistence tube employing a 2,000 v. anode and a 4 v. filament. The base is side contact. All VCR97's are tested and carefully repacked before dispatch.

CLYDESDALE'S PRICE ONLY 35/- each POST PAID

THE I.F. VIDEO AMPLIFIER

THE R.1355 provides an excellent basis for the vision receiver for your TV and provides 5 stages of I.F. (SP61) plus a detector (EA50) Video amplifier and cathode follower (SP61). The I.F. is 7.5 Mc/s. This unit is designed for use with the RF Units 24, 25, 26 and 27. The R355 can also be used for TV sound reception and the installation of integral A.C. Mains power packs is quite easily accomplished. Enclosed in a metal retainer. 18in. x 8½in. x 7½in.

CLYDESDALE'S PRICE ONLY 67/6 each POST PAID

Circuits available at 1/3 each.

12·25 Mc/s. I.F. STRIP

H.38 I.F. STRIP by Pye provides a very compact I.F. sub-chassis for use of SP61 valves (not included)—the chassis is wired for I.F. operation and input leads are tag terminated at rear end of unit. Coax input and output sockets are mounted on the front panel. Dim. 18in. x 5½in. x 4½in.

CLYDESDALE'S PRICE ONLY 17/6 each POST PAID

R.F. STAGES FOR T.V.

THE RF24 (30 to 20 Mc/s.-10-15 Metres) and RF25 (50 to 40 Mc/s.-6-7.5 Metres) are spot tuned converter units which are used with the R.1355 Receiver but can be fed into any Receiver which tunes 7 Mc/s. (42 Metres) Short Wave. 5 channels are pre-tuned and switched. These units consist of an RF stage (SP61), Mixer (SP61) and Oscillator (SP61) stage. Enclosed in a metal case 9½in. x 7½in. x 4½in.

CLYDESDALE'S PRICE ONLY 12/6 each POST PAID

CAN WE HELP YOU?

Circuits and details of numerous ex-surplus units available at low prices. Maybe we can help you to overcome that snag. Write direct.

350/400 WATT (AERIAL) TRANSMITTER. RCA TYPE ET-4336 SERIES

THE ET-4336 TX employs 2:813 valves in the P.A. modulated by 2:805 valves. An 807 Oscillator stage unit which is plugged into the front of the TX can be either a crystal multiplier or a master oscillator—BOTH ARE SUPPLIED. With each 4336 a further 807 buffer stage follows the Oxcillator. The ET 4336 is ready for use on A.C. Mains 200/250 volts and is fitted with a reduced power switch bringing the input within licence limits. Weight 550lb.

CLYDESDALE'S PRICE ONLY £60 F.O.B. Gt. Britain

HAND DRIVEN GENERATOR

H.409. Hand driven Generator 10K/13043, comprising a 40 : 1 gearing unit driving a generator producing 6.3 v. 5 A. and 300 v. 50mA. complete with ratchet handle. Dim. 7in. long. Used but in good condition.

CLYDESDALE'S PRICE ONLY 13/6 POST PAID

H.408. Hand Driven Generator by Bendix, comprising a 70 : 1 geared unit driving a generator producing 28 v. .175 A. and 300 v. at 40mA. The generator is detachable measuring 4½in. x 2½in. The unit is complete with ratchet handle. Used but in good condition.

CLYDESDALE'S PRICE ONLY 13/6 POST PAID

MAGNETIC COMPASS

H.406. Magnetic marching compass MK1, for day or night use, enclosed in a black bakelite case 3in. x 2½in. x ¾in., complete with instructions for use.

CLYDESDALE'S PRICE ONLY 21/- each POST PAID

POWER UNIT. For the P40 receiver. An A.C. mains power unit complete and ready to plug into a mains supply of 0-200/250 V. 40/60 cy. A.C., with an output of 175 v. at 60 mA. H.T. and 12.5 v./2.5 A. L.T. Totally enclosed in louvred metal cabinet. 11½in. x 5½in. x 4½in.

CLYDESDALE'S PRICE ONLY 39/6 each POST PAID

FLASH! NEWS FOR THE COMMERCIAL RADIO CONSTRUCTOR

WALNUT WOODEN CABINETS

A professionally built finely finished walnut wooden cabinet with inside dimensions 15¾ x 8½ x 7½in. complete with a finished dial aperture in the front 5¾ x 3½in. and a speaker aperture 5¾ x 4½in. Three holes are drilled symmetrically below the dial aperture. This is the type of cabinet which will make many want to build that new house set. Refer H394.

CLYDESDALE'S PRICE ONLY £1.5.0 each POST PAID

DIAL GLASS (Graduated) H 410

A three WAVEBAND DIAL GLASS to suit the cabinet detailed on the left, completely graduated with station names and wavelength. Dimensions 6 x 4in.

CLYDESDALE'S PRICE ONLY 1/3 each POST PAID

CONTROL KNOBS

H.403. Ivory Control Knobs 1½in. diam. ½in. deep with serrated edge. These knobs fit a standard ¼in. spindle with slotted side and are spring clip locked.

CLYDESDALE'S PRICE ONLY 9d. each POST PAID

H.404. These knobs are as above but finished in brown.

CLYDESDALE'S PRICE ONLY 8d. each POST PAID

WAVECHANGE SWITCH

H.393. An extremely robust yet compact 2 wafer switch, 3-pole 4-way each section. 2in. between each wafer with a spindle 1½in. long, standard ¼in. diam. flattened.

CLYDESDALE'S PRICE ONLY 4/6 each POST PAID

CONDENSERS

H399 TWO GANG VARIABLE TUNING CONDENSER less trimmers .00035 Mfd. nom. with ¼in. spindle ¾in. long. Dimensions, 2¼ x 2¼in.

CLYDESDALE'S PRICE ONLY 7/6 each POST PAID

MEDIUM and LONG WAVE PADDERS, 150 and 400 Pf. respectively. These two trimmers are mounted in a single ceramic block fitted with a small bracket for mounting purposes.

CLYDESDALE'S PRICE ONLY 1/- each POST PAID

H400 8 Mfd. 450 v. Wkg. ALI-CAN ELECTROLYTIC CONDENSER, 2½ x 1in. diam.

CLYDESDALE'S PRICE ONLY 2/9 each POST PAID

H400A MOUNTING CLIPS for the above condenser.

CLYDESDALE'S PRICE ONLY 4d. each

H401 16 x 24 Mfd. 450 v. Wkg. ALI-CAN ELECTROLYTIC CONDENSER, 2½ x 1¾in. diam.

CLYDESDALE'S PRICE ONLY 4/6 each POST PAID

H401A MOUNTING CLIPS, for the above condenser.

CLYDESDALE'S PRICE ONLY 3d. ea. 2/6 doz. POST PAID

FOR THE 2-METRES ENTHUSIAST

P40 VHF Superhet Receiver provides yet another basis for that 2-metre rig. We can supply you with this Stratton-built receiver which can be modified for use on 144 Mc/s. The set in its present state can be tuned to any spot frequency between 85 and 95 Mc/s. by means of the crystal controlled Oscillator stage which should not prove unduly difficult to alter, and pruning the coils is quite simple. REMEMBER the P40 would make a fine business mobile receiver for 2 metres.
Employing an I.F. of 2.9 Mc/s. the valve line up includes—1:EF54 RF, 1:EF54 Mixer, 1:EC52—2:EF54 Oscillator and multiplier stage, 2:EF39 I.F., 1:EB34 detector and AVC, 1:6J5 1st Audio and a 6V6 output.
The complete unit is enclosed in a die-cast frame with a louvred cover. Dimensions 11½in. x 5½in. x 4½in.

CLYDESDALE'S PRICE ONLY £3.19.6 each POST PAID

Order direct from :—

CLYDESDALE SUPPLY CO LTD. 2 BRIDGE STREET GLASGOW - C.5

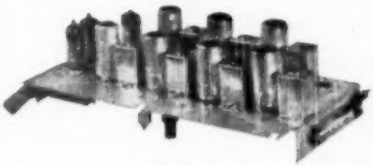
Branches in Scotland, England and Northern Ireland.

ALWAYS FIRST WITH THE FINEST.

LASKY'S RADIO

World Renowned for Service & Reliability

COMPLETE SOUND / VISION TELEVISION RECEIVER.



Model A—London. B—Birmingham. By well-known British manufacturer. Uses 10 of the latest type miniature valves. Specification and line up: Vision. 3 R.F. stages with 6AM6's. Det. and int. suppr. 6AL5. Sep. Sep. 6AM6. Video output 6AM6. Sound: 3 R.F. stages with 6AM6's. Det. and int. suppr. 6AL5. Sound output 6AM6. Size of unit: 10in. × 4in. × 7in. Circuits and full data supplied with each unit. Remember these are brand new manufacturers' surplus and not Ex-Government. COMPLETE WITH VALVES.
Voltages required: H.T. 270 volts, 80 m.a., L.T. 6.3 volts 3 amps.

LASKY'S PRICE **£6.19.6** Carriage and packing 2/6 extra.

STILL AVAILABLE. As advertised in November issue.
WALNUT CONSOLE TELEVISION CABINETS. 9", 10" and 12".
LASKY'S PRICE **£8.10.0** Carriage 12/6 extra.

L.S.L. VALVE AND CIRCUIT ANALYSER. BRAND NEW.
LASKY'S PRICE **£10.19.6** Carriage 10/- extra.

EX. A.M. RECEIVER TYPE R1155A. BRAND NEW AND UNUSED. IN MAKER'S ORIGINAL WOOD CASE. High frequency receiver. 100-124 Mcs. Contains 11 valves: one VR91, one VR66, four VR91, two VR54, one 6J5, one VR70 (voltage stabiliser), one VR37. Large tuning scale, with slow motion drive. 0-6 m.a. tuning meter, R.F. and L.F., gain controls, jack sockets for line and 'phone. Totally enclosed in metal case, grey enamelled, with plated handles. Size: 19in. × 10in. × 11in. Weight packed 34lb.
Supplied with circuit and calibration chart.

LASKY'S PRICE **99 6** Carriage 10/- extra.

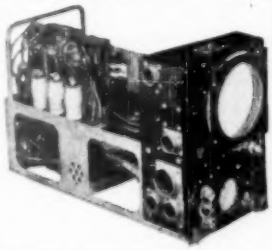
COMMUNICATIONS RECEIVER. TYPE P.C.R. By Philips. Perfect condition. Aerial tested before despatch. 6 valve superhet, 60-550 kcs. R.F., F.C., two I.F.s, D.D.T., pentode output. Frequency coverage 16-50 mtrs., 200-750 mtrs., 980-2,200 mtrs. Fitted in metal case, black crackle finish, with built-in loudspeaker. Fly wheel tuning. May be used with any suitable power pack. Supplied complete with 6 brand new Mullard valves: 3 EF39, 1 ECH35, 1 EBC33, 1 EL32.

LASKY'S PRICE **£10.10.0** Carriage 10/- extra.

Power pack for P.C.R. Receiver. 12 volt.
LASKY'S PRICE **39 6** Carriage 5/- extra.
A few only. A.C. power packs.
LASKY'S PRICE **59 6** Carriage 5/- extra.

TUNEABLE PRE-AMPLIFIERS. Ideal for use with our 10in. or 17in. television receivers. This compact and efficient pre-amplifier can be tuned to any of the B.B.C. frequencies both in use and proposed. Is for use in fringe areas and gives a gain of approximately 25 times. It can be used on any receiver where the aerial impedance is 80 ohms. One valve is used—Osram 2.5. It is simple to connect, a standard Belling Lee co-axial plug and socket for input and output, and standard 4-pin plug for power supply, the latter fitting the socket at the rear of our television receivers.
Size: 4in. × 2½in. × 3in. In grey cracked metal case.

LASKY'S PRICE **42 -** Postage and packing 3/6 extra.

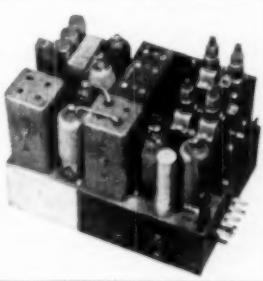


RADAR INDICATOR UNITS TYPE 1690. BRAND NEW IN MAKER'S ORIGINAL WOOD CASE. Contains 2 cathode ray tubes, one 5in. VCR517 and one 3in. VCR139. Also the following valves: three 6P61, one 6J5, three EA50, one D1. Dozens of components, coils, resistances, condensers, seven potentiometers, etc. Enclosed in metal case, size 12in. × 9in. × 19in. Weight 40lb.

LASKY'S PRICE **79 6**
Carriage 7/6 extra.
The 1690 Indicator. Less the VCR139.
LASKY'S PRICE **59 6**
Carriage 7/6 extra.

RECEIVER UNITS TYPE 25.
The receiver section of the TR1196 equipment. Easily converted to an all-wave receiver. 6 valve superhet. Valve line-up: two EF36, two EF39, one EK32, one EBC33. Full details and circuits supplied free with each receiver. Slightly soiled but unused.

LASKY'S PRICE **22 6**
Carriage 2/6 extra.
The Receiver 25, less valves.
LASKY'S PRICE **8 6**
Carriage 2/6 extra.



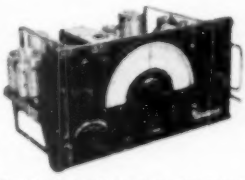
BRAND NEW EARPHONES. High resistance.
LASKY'S PRICE **7/6** per pair.
Postage 1/- per pair extra.
CAR RADIO PLUG SUPPRESSORS. Brand new and perfect.
LASKY'S PRICE **1/-** each. 10/- per doz.
Post extra.

CONDENSER CORNER. By famous Manufacturers. All new goods fully guaranteed.

mfd.	w.v.		mfd.	w.v.	
2	350	1/-	25	25	1/6
4	350	1/3	50	12	1/-
4	500	2/-	64	450	5/11
5	500	2/-	8 × 8	150	2/6
5	500	2/6	8 × 8	500	4/6
12	50	1/-	8 × 16	450	4/3
16	500	3/-	8 × 16	500	4/11
20	12	1/-	16 × 32	350	4/11
			32 × 32	350	4/11

AUTO TRANSFORMER. Type ATS. 70 watts. Voltages: 100, 110, 130 and 240. Step up or down.
LASKY'S PRICE **7/11**
Postage 1/- extra.
VA26 PHOTO ELECTRIC CELLS. Requires 100 volts D.C. or peak A.C. to function. Brand new and perfect.
LASKY'S PRICE **12/6**
Post 1/6.
931A Photo electric cell with 9 stage multiplier. Suitable for telephoto and low light experimental work. BRAND NEW AND GUARANTEED. Full data and details supplied with each cell.
LASKY'S PRICE **25/-**
Post 1/6.
CRYSTALS. Germanium Crystal Diodes.
LASKY'S PRICE **3/6** each.

EX-A.M. COMMUNICATION RECEIVER TYPE R1155.



BRAND NEW IN WOOD TRANSIT CASE. Aerial tested before despatch. Supplied complete with 10 valves. Circuit: R.F.O., A.V.C., R.F. Amp., two I.F. stages, magic eye, etc.
5 frequency ranges: 18.5-7.3 Mcs.; 7.8-3.6 Mcs.; 1,500-600 kcs.; 600-300 kcs.; 300-75 kcs.
LASKY'S PRICE **£12.10.0**
Carriage in wood case: 7/6 extra.
Full modification data and circuit details supplied free with each receiver.
Complete kit of parts, including output valve and rectifier for building a power pack and output stage for the T1154 Receiver as described in the modification instructions.

PRICE **56 -** Complete, carriage free.

The above power pack and output stage fully assembled in black enamel case, ready for use.

PRICE **79 6** Carriage 5/- extra.

Send a 2½d stamp with your name and address (In block letters please) for a copy of our current stock list giving full details of our Ex-Government Radio, Radar and Surplus equipment, THE LASKY'S RADIO BULLETIN

370 HARROW ROAD, PADDINGTON, LONDON, W.9

(Opposite Paddington Hospital)

TELEPHONE: CUNningham 1979 & 7214. Hours: Mon. to Sat. 9.30 a.m. to 6 p.m. Thurs. half day 1 p.m.

You're SURE to get it at

STERN'S

ESTABLISHED 25 YEARS

Moving Coil Speakers. All new 2/3 ohms P.M.: 3in., **11/6**; Rola **16/6**; 4in. **18/-**; 5in. **10/-**; (with Trans. **14/6**); 6½in. **11/6**; 8in. **12/6** and **17/-** (with Trans. **16/-**); 10in. **23/6**; 12in. Rola **39/6** and Celestion **75/-**.

Potentiometers. New Centralab: 2K, 5K, 10K, 25K, 50K, 100K, ¼, ½, 1 and 2 meg., less switch, **3/9**, with switch **6/-**. Midget Type **2/6**. Midget with switch, ¼, ½ and 1 meg., **6/-**.

Surplus Potentiometers. All standard size with extended spindles: 5K, 10K, 15K, 20K, 25K, 50K, 100K, 250K, 500K, 750K, 1 meg. **2/6** each.

Coils. Denco Maxi "Q" High "Q" with miniature size Litz wound on Polystyrene Formers with adjustable Iron Dust Cores. Aerial, H.F., or the Oscillator for 465 k/c or 1.6 m/c. Range covers all wavebands from 3.6 to 2,000 metres. Wiring diagram. **Prices:** Chassis Mounting, **3/9** (with Reach, **4/9**). Octal fitting pin base, **4/-** (with React., **5/-**). **Denco** T.R.F. Matched pair Medium and Long Waves, **6/6** pair. Weymouth T.R.F. Matched pair M. and L. Waves, **9/6** pair. Superhet Matched pair S. M. and L. Waves **8/9** or **11/6** pair. All types Wearite "P" Coils, **3/-** each in stock. Weymouth Midget 1¼in. × ¾ dia., Iron Core Aerial H.F. or Osc., **3/6** each.

Electrolytic Condensers. B.E.C. Midget Can Tubular, 8 mfd. 450 v. (1¾in. × 1in. dia.), **2/6**; 8-8 mfd. 450 v. (1¾in. × 1in. dia.), **4/-**; 16-8 mfd. 450 v. (1¾in. × 1in. dia.), **4/6**; 32 mfd. 450 v., **5/-**; 16-16 mfd. 450 v. (1¾in. × 1¼in. dia.), **4/6**; Dubilier "Drilitic" Card Tubular, 4 mfd. 500 v., **3/6**; 8 mfd. 500 v., **4/-**; 16 mfd. 500 v. **5/6**; B.I. Can, standard size, 8 mfd. 500 v., **3/9**; 8-8 mfd. 500 v., **5/-**; 16 mfd. 500 v., **4/3**; 16-16 mfd. 500 v., **5/3**; 32 mfd. 350 v., **5/-**. All New Stock. Dubilier mica .001 mfd. 2,000 v., **2/6**.

Denco I.F. Liner for accurately lining-up 465 k/c. or 1.6 m/c I.F. channels. Pre-tuned circuits, battery operated and completely self-contained. Price **42/-** (incl. P.T.).

Coil Packs. Osmor Midget Coil Pack, Size 3¼in. × 2¼in. × 1¾in. covering S. M. and L. Waves. Coils wound on Polystyrene Formers with adjustable Iron Cores ensures efficient performance. Factory wired and aligned. Price, including full circuits for Superhet 465 k/c. Unit, **33/-**. Plus 7/4 P.T. **Weymouth** Midget 3¼in. × 2¼in. × 1¾in. covering S-M-L W/Bands, for 465 k/c, employing Matched Iron Cored Coils on each W/Band, **42/10**. **Wearite** Superhet Type 703 and 706, size 4¼in. × 3¾in. × 1¾in., covering two Short Wave and one Medium W/Band or S-M-L Wavebands, 465 k/c, employs Iron Cored Coils **37/10**. All of the above Coil Packs include Switching, Padding and Trimmer Condensers.

Output Transformer—Stern's. Midget 1¾in. × 1¼in. × 1in. ratio 60-1, **3/9** (or ratio 90-1, **3/9**). Stern's Multi-ratio (over 12 ratios, some C.T.), 5/6 watts **8/6**. Stern's Heavy Duty Multi-ratio all C/Tapped. Handles 15 watts and suits P.X.4s, 6L6s, etc., **29/6**. Rola Multi-ratio, 5/6 watts, **10/6**.

L.F. Chokes. Midget 10 henry 350 ohm 40 mA., **3/6**; 20 hny. 250 ohm 60 mA., **6/6**; 20 hny. 300 ohm 100 mA., **11/9**; 5 hny. 50 ohm 250 mA., **18/6**; 20 hny. 250 ohm 120 mA., **18/6**; 9 hny. 250 ohm 150 mA., **8/6**.

Aluminium Chassis. Substantially made of gauge 18 S.W.G. with four sides, 7in. × 4in. × 2in., **3/3**; 9in. × 5in. × 2½in., **4/-**; 10in. × 6in. × 2½in., **4/11**; 10in. × 8in. × 2½in., **5/6**; 12in. × 9in. × 2½in., **6/8**; 14in. × 9in. × 2½in., **6/11**; 16in. × 8in. × 2½in., **7/3**; 20in. × 8in. × 2½in., **8/6**.

I.F. Transformer, 465 k/c. New well-known manufacturer's surplus ¾in. × ¾in. × 1¼in. Iron Core, **9/-** each. Denco Iron Core, 465 k/c. or 1.6 m/c. 1¼in. × 1¼in. × 2¼in., **16/6** pair. Wearite Stand Cap. Tuned, 465 k/c., **20/-** pr. New Surplus 465 k/c. Iron Core, 4in. × 1¼in. sq., **10/-** pair.

Meter Rectifiers. Westinghouse 250 micro-amp., **11/6**; 1 mA., **10/6**; 5 mA., **4/9**.

Selenium Rectifiers. H.T. H. wave 250 v. 50 mA. **5/6**; 250 v. 100 mA. **7/6**; 250 v. 175 mA. **13/9**.

F. Wave Bridge Rectifiers for Battery Charging or Models 2, 4 or 6 v. 1½ amp., **7/6**; 6 or 12 v. 1½ amp. **11/6**; 6 or 12 v. 3 amps. **19/6**; 6 or 12 v. 5 amps. **23/-**; 12 or 24 v. 3 amps. **23/-**.

Variable Resistor to control charging (or model speed) up to 3 amp. rating. **13/6**. Suitable METER **5/9**.

Charger Transformers. Suitable for use with above Rectifiers. Each has input of 230 volts. Outputs (a) 24 volts tapped 15 v., 9 v. and 4 v. at 3 amps., **22/9**; (b) 30 volts tapped 15 v. and 9 v. at 3 amps., **23/9**; (c) 15 volts tapped 9 v. at 3 amps., **16/6**; (d) 12 volts, 1½ amps., **11/3**; (e) 15 volts tapped 9 v. at 6 amps., **21/6**; 15 volts tapped 9 v. at 1½ amps., **13/6**. A Battery Charger Wiring Diagram is included with purchase of Charger Transformer and Rectifier.

NEW SURPLUS ! ! FOSTER TRANSFORMERS. PRIMARY 230 VOLTS. SECONDARY 18 VOLTS, 9 AMPS. 21/-.

Filament Transformer. Inputs 230 volts, outputs 6.3 v. 1½ amp., **8/3**; 4 v. 1½ amp., **7/6**; Input 200/250 v., output 4 v. (C.T.) 1½ amp., 4 v. 2 amp., 6.3 v. 2 amp., **19/6**. Input 230 v., output 6.3 v. (C.T.) 4 amp. **16/6**.

Westinghouse Rectifiers. (a) H.T.51. Rated 350-0-350 volts 100 m/a., **35/-**; (b) H.T.52. Rated 350-0-350 v., 200 m/a., **37/6**; (c) H.T.53. Rated 500-0-500 v., 200 m/a., **50/-**; (d) Type 16H.T.56, **17/9**; (e) Type 36E.H.T.2?, **11/9**; (f) Type 36E.H.T.35. Rated 2.5 kV., 1 m/a., **17/6**; (g) Type 36E.H.T.100. Pulse rating 5/6kV., **28/3**.

Mains Transformers. All New Stock with Primaries tapped for 200-250 volts. Secondaries: (a) 250-0-250 volt, 80 m/a., 6.3 v. (Tapped 4 v.) 4 amp and 5 v. (Tapped 4 v.) 2 amp., **18/6** (also available with 350-0-350 volt at **18/6**). (b) Stern's 350-0-350 volt, 110 m/a., 6.3 v. (Tapped 4 v.) 4 amp. and 5 v. (Tapped 4 v.) 2 amp., **38/6**; (b) 350-0-350 v. 250 m/a., 4 volt 8 amp., 4 v. 3 amp. 6.3 v. (Tapped 2 v.), 2 amp. and 6.3 v. 6 amp. **72/6**, and many to other ratings.

Heater Auto Transformers: (a) Tapped 2 v., 4 v., 5 v., and 6.3 volts 3 amp., **9/6**; (b) 4 v. 2 amp. to 5 v. 2 amp. Reversible **6/-**; (c) 4 v. 3 amp. to 6.3 v. 2 amp. Reversible, **6/-**.

Power Potentiometers. Bulgin adjustable slider type max. 6 ohms 60 watt, or 14 ohms 60 watt, **13/6** each. Ex-Govt. Rotary Adjustable 50 ohms 60 watt **5/9**.

A 4 Station Pre-set Tuner. A complete self-contained unit from which any 3 Medium W/Band and 1 Long W/Band Stations may be pre-selected, and then individually selected by turn of Rotary Switch. No Tuning Condenser required, only 4 connections are necessary, price **40/-**.

Adjustable Mains Droppers. 1¼in. dia. × 2¾in.: (a) .15 amp., 1500 ohms, **5/-**; (b) .2 amp., 1,000 ohms, **4/3**; (c) .3 amp. 600 ohms, **5/-**.

6 Volt Vibrator Transformers, secondary 350-0-350 volts 80 m/a., **8/6**.

KITS OF PARTS AND CONSTRUCTORS ASSEMBLY OUTFITS

A 4-STATION "PRE-SET" RECEIVER. We now have available complete Assembly Instructions for the construction of a midget "**Pre-Set**" **Superhet Receiver**, showing also, Wiring Diagram, Component Layout, Point-to-Point connections and Component List. This Set will select 4 Stations, 3 on **MEDIUM** and 1 on LONG WAVE BANDS, by the turn of a Rotary Switch, no tuning being necessary. It is of midget size, the completed Chassis being 5¼in. × 4¼in. × 7in. high, simple to assemble, and can be completely built, including Valves and Moving Coil Speaker, etc., for **£5/17/6**. Price of Circuit and Instructions, **1/6** (plus 2d. Post).

"MAINS or BATTERY PERSONAL KIT"

A complete KIT OF PARTS to build our new **MIDGET** 4-VALVE SUPERHET PERSONAL SET, covering **MEDIUM** and **LONG WAVES** and designed for **MAINS** or BATTERY operation is now available.

This 2 Waveband Superhet Receiver is designed to operate on A.C. mains 200/240 volts, or by an "All Dry" Battery, either method being selected by means of a Rotary Switch. It is so designed that the Mains Section (size 4¼in. × 1¾in. × 3¼in.) is supplied as a separate Kit, which may be added at any time. The kit therefore can be supplied either as an "All Dry" Battery Personal Set, or as a Midget Receiver for combined Battery/**Mains** operation.

The circuit incorporates Delayed A.V.C. and Preselective Audio Feedback. A Rola 4in. **P.M.** Speaker with generous size Output Transformer ensures excellent quality reproduction. Ready Wound Frame Aerial, Fully aligned I.F. Transformers, and a Drilled Midget Chassis are included. Valve line up—1.R.5 (F.C.), 1.T.4 (I.F. Amp.), 1.S.5 (Diode Det and Audio Amp.) and 3.S.4 (Output Tet).

The Set is quite easily built from the very detailed assembly instructions supplied, which include a practical component layout, with point to point wiring, and a circuit diagram for both the Set and the Mains Unit.

Price of COMPLETE KIT (less Mains Unit), **£6/13/9**. Price of COMPLETE MAINS UNIT KIT, **£1/17/6**. EVER READY Type B114 BATTERY, **9/7**.

An attractive Walnut Finished Cabinet, size 9in. × 5¾in. × 5¼in., of the hinged lid type and suitable to house the combined set is available for **19/9**.

THE COMPLETE ASSEMBLY INSTRUCTIONS mentioned above can be supplied separately for **1/9**.

A Midget T.R.F. Battery Portable "Personal" Kit. A complete Kit of Parts to build a Midget 3-valve All-dry Battery Personal Set. Consists of Regenerative T.R.F. Circuit employing Flat Tuned Frame Aerial, with Denco Iron Dust Cored Coil thereby ensuring maximum gain for Single Tuned Stage covering Medium Waveband.

Valve line-up: 1T4 (R.F. Amp.), 1T4 (Detector), 1S5 (1st A.F.) and 3S4 (output). Includes latest Rola 3in. Moving Coil Speaker, and a Chassis already drilled and shaped. A consumption of only 7 mA. ensures long battery life. The Kit is designed for a cabinet, minimum size 8in. × 4¼in. × 5in. Detailed Building Instructions with Practical Layout and Circuit included with Kit make assembly easy. **Price for Complete Kit, £3/18/9** (plus **16/7** P.T.). Suitable unpolished Cabinet 6¼in. × 4¼in. × 7in., **12/9**. Ever Ready B114 Battery, **9/7**. Building Instructions, Circuit, etc. supplied separately, **1/-**.

A Complete Kit of Parts to build a **Midget "All Dry" Battery Eliminator,** giving approx. 69 volts H.T. and 1.4 volts L.T. This Eliminator is suitable for any Personal Set requiring H.T. and L.T. voltages indicated above. The Kit is quite easily and quickly assembled and is housed in a Light Aluminium Case, size 4¼in. × 1¾in. × 3¼in. It can therefore be accommodated inside most makes of Personal Sets. Price of Complete Kit, **£1/17/6**.

"Wireless World" Midget A.C. Mains 2-Valve Receiver. We can supply all the components, including valves and M/Coil Speaker to build this set as specified in the March issue at a total cost of **£3/5/0**. Reprint of detailed assembly instructions and circuit supplied separately for **9d.**

"Wireless World" Midget A.C. Mains 3-Valve Receiver. Covering Long and Medium Wavebands. We can supply all the Components, including Drilled Chassis, Valves, Moving Coil Speaker, etc., to build this Set, as specified in the Feb. issue, at a total cost of **£4/10/0** including a reprint of the complete Assembly Instructions and Circuit (this is available separately for **9d.**) and Practical Components Layout with "point-to-point" connections. An attractive **Walnut Finished Cabinet** is now available for this W. World 3-Valve Set at **21/-**, or it can be supplied with a complete Dial and Drive Assembly which includes the latest Station Name Dial and Dial Escutcheon, and a Combined Switch/Volume Control to effect very slight modification. Inclusive price, **35/-** (Dial and Drive Assembly with Switch/V. Control supplied separately for **14/-**.)

We can supply all the Components, including Valves, M/Coil Speaker, etc., **to build a Midget A.C./D.C. Mains T.R.F. 3-Valve (Plus Metal Rectifier) Receiver** as designed and specified by a popular Technical **Magazine**, at a total cost of **£4/17/6**. A reprint of the assembly instructions, and layout available for **9d.**

An Entirely Complete 3-Valve Amplifier Kit of Parts. Operating on A.C. or D.C. mains 200-250 volts. Has an output of max. 4 watts, with valve line-up 25A6, 6J7 and U31. A matched 6½in. Moving Coil Speaker is supplied. Price, including Wiring Diagrams **75/-** (or less M/Coil Speaker, **59/6**).

"ELECTRONIC" VALVE VOLTMETER. We can supply the COMPLETE KIT OF PARTS, including the Valve, Diode and **Meter**, etc., to build this instrument, as published in the January issue of "Electronic Engineering," complete with a reprint of the wiring diagram and assembly instructions (supplied separately for **9d.**) at a total cost of **£3/15/-**.

TELEVISION — The **"Viewmaster" Televisor** assembly instructions showing Wiring Diagram and Practical Component Layout **available for 5/-**. We have the specified Components, including the T.C.C.—Bulgin—**Morganite**—W.B.—Westinghouse—Plessey—Colvern, etc., (mostly) in stock. We can supply this Televisor by the individual stages (as published with the instructions) or by separate Components. Complete price details can be obtained on application.

THE "EASYBUILT" TELEVISOR. Full constructional data now available in book form, showing Wiring Diagram, Practical Component Layout and "point-to-point" connections, make this one of the most suitable Televisors for the Home Constructor to build. The specified Components are all available at very reasonable prices, enabling the set to be completely built for approx. **£20—£23** including Valves, but excluding C.R.T. Price of complete Manual **2/6**.

★ Send 1d. stamp for our Comprehensive Stock List. When ordering please cover packing and postage.

STERN RADIO LTD., 109 and 115 FLEET STREET, E.C.4

Telephone: CENtral 5814 and 2280

M·O·S AMPLIFIER

HIGH QUALITY at LOW COST

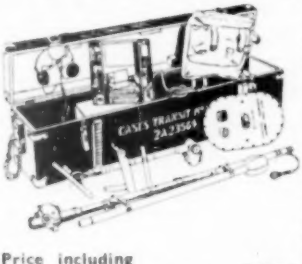
The M.O.S. Amplifier Type A1 is specially designed for home use. It is a simple, straightforward design, but by careful choice of circuit values reproduction obtained is excellent. Thus, high-quality equipment is placed in a price-range to suit everybody. Crystal pick-ups are recommended for use with this Amplifier, but ordinary magnetic types can be used if so desired. The Amplifier is offered as a complete kit which can be constructed easily in a few hours by anyone, so that even the non-technician can build the equipment, which is in the high-fidelity class, quickly and without trouble. The kit is complete with all necessary components and valves, down to the last nut and bolt, and includes full assembly instructions, wiring diagrams, parts list, etc. All Resistors and Condensers are pre-assembled on a moded group board.

Complete Kit For A.C. Mains operation **82/6**

10 P.M. TRUVOX Loudspeaker ONLY 15 11 extra

The complete set of technical data and instructions is available separately for only 3/6 post free. Desk Microphone 7/6 extra.

METAL DETECTION KIT



Owing to stocktaking we are now clearing our remaining stocks of these Mine Detectors at a ridiculous price. It is anticipated that the demand will be heavy so—order now! These are absolutely complete and have never been used, but are store soiled.

LET'S EXPLORE—

the possibilities of using one of our Mine Detectors! If you are geologist, archæologist, plumber, surveyor, excavator, builder, municipal engineer or veterinary surgeon you will definitely need one. Designed for the location of metallic objects under ground or water they will also detect the presence of metals in any place where they have no business to be.

EQUIPMENT

3-valve battery operated amplifier in steel case, shoulder harness, two search coils with poles, junction boxes, headphones, 9 spare valves, circuit diagrams, log book, connecting cables and sensitivity measuring stick, operating instructions. Ready for use as soon as batteries are connected. Packed in robust transit case.

Price including working drawings **22/6**

Carriage and packing 12/6

D.C. "STEP UP" GENERATOR

A Universal Purpose Motor generator fully guaranteed, brand new and in original maker's cartons. This unit can be driven from D.C. voltages from 2 v. to 14 v. and will give varying outputs according to the input voltage. For example: at 6 v. D.C. input an output of about 2½v., 30 m/a will be obtained. At 4 v. D.C. input, 180 v., 20 m/a will be obtained. At 12 v. D.C. input 450 v., 40 m/a will be obtained. The motor will also provide sufficient power for use as a grinder, polisher, etc., as a spindle protrudes from the casting of sufficient length for mounting these. Approx. R.P.M. at 12 v. D.C. input, is 2,000 (varying according to the applied voltage).

THE COST OF MANUFACTURING THESE USEFUL EQUIPMENTS WAS APPROX. £8-£9.

OUR PRICE **8/11** *Post and Packing 1/1*

REMEMBER: EACH ONE CARRIES FULL GUARANTEE

BURGOYNE SOLDER GUN

The Burgoyne Solder gun needs no introduction. It is the finest soldering instrument for radio and television engineers. No wasted electricity. No element to burn out. Press the button, count seven and the job is done.

Brand New and Boxed. 2-year guarantee. List Price 79/6.

OUR PRICE **52/6** Post Free.

500 YDS. of LIGHT! THE KING OF TORCHES

22/6 *Post free*

Type H. 5-cell 15 long 2½ dia. head

The latest addition to our range of American Type long beam focussing torches. Uses five U2 batteries and has an adjustable ring focussing head. Solid brass, nickel-plated finish. Pull-out carrying loop in base, with spare bulb container inside torch case. Complete with British Batteries and bulbs.

Gives beam of 500 yards.

FULLY GUARANTEED

R.3515

21-valve radar units with six stage 14 MC I.F. Strip. There is sufficient space on the chassis to construct a complete T.V. receiver—excluding S.G.T. Valves: one EA50, ten SP61, five EF36, three EBC33, one EF39, one EB34 (See article May issue "Short Wave Listener"). BRAND-NEW IN TRANSIT CASES:

£3 10 0 (Carr. Paid)

B.S.R. TAPE AND WIRE RECORDER MOTORS

This small induction motor is specially designed for magnetic tape and wire recorders. Absolutely silent in operation and virtually free from vibration. Minimum error magnetic field for A.C. mains 100-250 volts 50 cycles.

Price **38/-** + Post Free.

BUILD THE "VIEWMASTER" FOR £5 DOWN

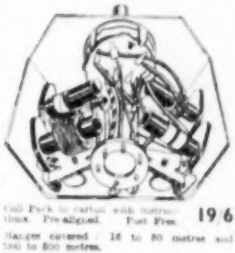
EXCLUSIVE H.P. OFFER

Ref.	Components	Deposit	12 Per-cents Monthly
		£ s. d.	£ s. d.
A	W.B. Sound and Vision Chassis. Timebase Chassis. Side Supports. Frame Transformer. Main Choke. Heater Transformer. Mains-cross. Speaker. Tube Supports	2 0 0	10 10
B	Sound and Vision Chassis. Timebase Chassis. Side Supports. Tube Supports	1 0 0	4 1
C	T.C.C. Condensers. LONDON	2 0 0	9 3
D	T.C.C. Condensers. MIDLAND	2 0 0	10 0
E	Washington Rectifiers	1 0 0	3 11
F	Finney Scanning Coil. Focus Ring. With Control. Line Transformer. Boost Choke	2 0 0	3 8
G	LONDON. Morganite Resistors. G Pile (1958, and Both) Set of Six Cathode Tube. Wearite Coils. Wearite R.F. Choke L.S. Boiling Connector and Switch. Bulgin Plug and Socket. Fuses	2 0 0	5 8
H	MIDLAND. As for G but including four Wearite Filter Coils	2 0 0	6 5
I	LONDON. Pre-amplifier Chassis. 8 Condensers. 3 Resistors. 2 Coils. 1 Valve. 1 Valve Base. With instructions	1 0 0	2 2
J	MIDLAND. Pre-amplifier. As for I	1 0 0	2 2
K	Conversion Kit-Table Model to Console Model. Plus Components as in A	2 0 0	12 9
L	Set of 12 Valves: 5—EF50, 1—EB91, 1—EBC33, 1—EL33, 2—EA50, 1—EF39, 1—EF39. Owing to variations in supply, we reserve the right to substitute recommended equivalents for the above.	2 0 0	9 5
M	9in. Cathode-ray Tube. Mullard MW22/14C	5 0 0	11 8
N	12in. Cathode-ray Tube. Mullard MW31/14C or MW31/17	5 0 0	18 7

We regret that we cannot supply C.R. Tubes alone on hire purchase. An order for a tube must be accompanied by an order for other Viewmaster Components. We also regret that our prospects cannot be splashy or altered.

TOTAL DEPOSITS MUST BE AT LEAST £5.

MINIATURE SUPERHET COIL PACK



This new M.O.S. coil pack of the smallest possible physical dimensions sets a new high standard in performance. It is of exceptionally high gain, and particular care has been taken in the design of the Short Wave range, which gives a performance equal to that normally obtained only on a communications receiver.

Winding of coils gives extremely high magnification in aerial circuit. Iron dust cores also ensure increased efficiency. While the coil pack is supplied pre-aligned and in this condition gives excellent results, slave stray capacities of the various circuits in which it is used will vary, the trimmers and cores have been arranged to be readily accessible for small final adjustments to ensure maximum performance. Overall size: 2½in. deep × 2½in. wide × 1¾in. high.

All connections are via a small circular terminating strip on rear of coil unit. This can be placed over frequently changed, giving shortest possible circuit leads.

Coil Pack in carton with instruction sheet. Pre-aligned. Post Free. **19/6**

Ranges covered: 16 to 50 metres and 190 to 500 metres.

TRADE AND WHOLESALE TERMS AVAILABLE ON APPLICATION

M-O-S "FULVISION" DIAL ASSEMBLY

A brand new 3 waveband full vision dial assembly, one 6in. wide, 4½in. high. Vertical tuning scales.

Dial arranged for back illumination printed three colours on unbreakable "Perspex." Clever arrangement of nylon cord drive makes action truly non-slip. Dial, backing plate and pulley, drive spindle, pointer with nylon cord attachment, reduction drive drum, dial locating bracket, and full assembly instructions in sealed carton.

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21 Valves. Suitable for 9in. 10in. and 12in. Magnetic Tubes: Less Tube, tube holder and Mask. Chassis all stamped out. State whether for Sutton Coldfield or Alexandra Park. Complete with booklet, instructions, etc. £31 12s. 6d., carr. paid.

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HSM63. (Midget). Output 250-0-250 v. 60 m/a. 6.3 v. at 3 amps., 5 v. at 2 amps. 15/-
HS63. Output 250-0-250 v. 60 m/a. 6.3 v. at 3 amps., 5 v. at 2 amps. 15/6
HS60. Windings as above. 4 v. at 4 amps., 4 v. at 2 amps. 15/6

Output

HS2. 250-0-250 v. 80 m/a. 17/6
HS30. 300-0-300 v. 80 m/a. 17/6
HS3. 350-0-350 v. 80 m/a. 17/6
HS2X. 250-0-250 v. 100 m/a. 19/6
HS75. 275-0-275 v. 100 m/a. 19/6
HS30X. 300-0-300 v. 100 m/a. 19/6
HS3X. 350-0-350 v. 100 m/a. 19/6

Fully Shrouded

Output

FSM63. (Midget). Output 250-0-250 v. 60 m/a. 6.3 v. at 3 amps., 5 v. at 2 amps. 15/6
FS2. 250-0-250 v. 80 m/a. 19/6
FS30. 300-0-300 v. 80 m/a. 19/6
FS3. 350-0-350 v. 80 m/a. 19/6
FS2X. 250-0-250 v. 100 m/a. 21/6
FS75. 275-0-275 v. 100 m/a. 21/6
FS30X. 300-0-300 v. 100 m/a. 21/6
FS3X. 350-0-350 v. 100 m/a. 21/6

All the above have 6.3-4.0 v. at 4 amps., 5-4.0 v. at 2 amps.

FS43. Output, 425-0-425 v. 200 m/a. 6.3 v. 4 amps. C.T. 6.3 v. 4 amps. C.T., 5 v. 3 amps. Fully shrouded 42/6
FS50. Output, 450-0-450 v. 250 m/a. 6.3 v. 2 amps. C.T. 6.3 v. 4 amps. C.T., 5 v. 3 amps. Fully shrouded 62/6
F30X. Output, 300-0-300 v. 80 m/a. 6.3 v. 7 amps., 5 v. 2 amps. Framed. Flying leads 26/6
F35X. Output, 350-0-350 v. 250 m/a. 6.3 v. 6 amps., 4 v. 8 amps., 4 v. 3 amps., 0-2-6.3 v. 2 amps. Fully shrouded 59/6
FS160X. Output 350-0-350 v. 160 m/a., 6.3 v. 6 amps., 6.3 v. 3 amps., 5 v. 3 amps. Fully shrouded 37/6
FS43X. Output, 425-0-425 v. 250 m/a., 6.3 v. 6 amps., 6.3 v. 6 amps., 5 v. 3 amps. Fully shrouded 57/6
HS6. Output, 250-0-250 v. 100 m/a. 6.3 v. 6 amps. C.T. 5 v. 3 amps. For receiver R1355. Half shrouded 24/6
HS150. Output, 350-0-350 v. 150 m/a. 6.3 v. 3 amps. C.T. 5 v. 3 amps. Half shrouded 25/9
F36. Output, 250-0-250 v. 100 m/a., 6.3 v. 6 amps. C.T. 5 v. 3 amps. Half shrouded 25/9
FS120. Output, 350-0-350 v. 120 m/a., 6.3 v. 2 amps. C.T. 6.3 v. 2 amps. C.T. 5 v. 3 amps. Fully shrouded 27/6
PR1.1. Output 230 v. at 30 m/a., 6.3 v. at 1.5/2 amps 19/6

The above have inputs of 200/250 v.

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F6. Output, 6.3 v. 2 amps. 7/6
F6X. Output, 6.3 v. 3 amps. 5/-
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F12. Output, 12.6 v. tapped 6.3 v. at 3 amps. 15/6
F24. Output, 24 v. tapped 12 v. at 3 amps. 21/6
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FU6 and F29 clamped with Flying Leads.
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F6/4. Output, four at 6.3 v. tapped at 5 v. at 5 amps. per winding, giving by suitable series and parallel connections 24 v. at 5 amp., 20 v. at 5 amp., 18 v. at 5 amp., 15 v. at 5 amp., 12.6 v. at 10 amp., 10 v. at 10 amp., 6.3 v. at 20 amp., 5 v. at 20 amp. 47/6
F5 and F6/4 framed with Flying Leads.

OUTPUT TRANSFORMERS

MOP1. Ratios 26, 46, 56, 66, 90, 120-1, 50 m.a. max current. C.T. for Q.P.P. Class B., etc. Secondary 2/4 ohms. Top panel and clamped ..... each 5/-
OP1. Midget Power Pentode, ratios 30, 60, 90-1, 40 m/a., Secondary 2/3 ohms. ..... each 3/2
OP2. Midget Pentode, ratios 45-1, Secondary 2/3 ohms, 40 m/a. ..... per dozen 33/-
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Choke C4. 60 m.a., approx. 8 H., 350 ohms 4/3
Choke C5. 40 m.a., approx. 5 H., 360 ohms 3/3
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HOLME MOSS TV CONSTRUCTORS

should begin operations. The latest information is that tests will be commencing in the New Year with full scale operation scheduled for mid-June. Buy your gear NOW, and be ready. The easiest method is utilising Radar Receivers which are precision built for sensitivity regardless of cost, and which are available at the moment ridiculously cheap. Your cost is kept to a minimum and you can incorporate the finished unit into a Televisor using any size tube if so desired. Remember, thousands of viewers are receiving satisfactorily well outside the supposed "fringe" areas because they have modified the finest equipment money could make. The "Inexpensive Television" booklet costs only 2/6, and describes how a variety of units can be modified. Several of the units specified are listed below.

RECEIVER R.1355 as specified for "Inexpensive Television." Complete with 8 valves VR65 and 1 each 5U4G, VU120, VR92, also a copy of "Inexpensive TV." ONLY **55/-** (carriage, etc., 7/6).

I.F. STRIP 194. Another of the units specified as an alternative for the "Inexpensive TV." A first-class strip giving tremendous amplification, and well recommended for constructors who have built televisors but have come "unstuck" in the vision or sound receiver. Complete with 6 valves VR65, and 1 each VR53 and VR92, and a copy of the book, which gives full details of conversion to both stations. Size 18in. × 5in. × 5in. ONLY **45/-** (Postage, etc., 2/6).

"PYE" 45 Mc/s I.F. Strip. Ready made for London Vision channel. Complete with 6 valves EF50 and 1 EA50, ONLY **60/-** (Postage, etc., 2/6).

RECEIVER R.3547. This contains the "PYE" Strip, which can be easily removed if desired, and also 15 valves EF80, 3 of EB34, 2 of SP61, and 1 each EA50, EBC33, EF36, also hundreds of resistors, condensers, etc. BRAND NEW IN MAKER'S CASES. ONLY **120/-** (Carriage 7/6).

RECEIVER R.3084. A very sensitive unit containing 7 valves EF50, 2 of EF54, and 1 each VU39A, HVR2, EA50, and also a 30 Mc/s I.F. Strip with 4 Mc/s bandwidth. BRAND-NEW IN MAKER'S CASES. ONLY **75/-** (Carriage 7/6).

10 VALVE 1¼ METRE RECEIVER ZC 8931. Another very popular superhet for long distance TV reception. Contains 6 IFTs of 12 Mc/s with 4 Mc/s bandwidth, and 6 valves VR 65, 2 of VR 92, and 1 each VR 136 and VR 137. Complete with modification data for both stations. BRAND-NEW IN MAKER'S CARTONS. ONLY 59/6. (Carriage 5/-.)

RF UNIT TYPE 25 for use with R.1355 for London reception. ONLY 17/6 (Postage 1/6).

RF UNIT TYPE 26 for use on Sutton Coldfield channels are now all sold, but we can supply one of the other RF Units with full details of easy modification for the **TV. BRAND NEW IN CARTONS.** ONLY **25/-** (Postage 1/6).

INDICATOR UNIT TYPE 6 as specified for "Inexpensive TV." Complete with VCR97 CR Tube, 4 valves EF50 and 3 of EB34. BRAND NEW IN MAKER'S CASES. ONLY **90/-** (Carriage 7/6). This unit is also specified for the "WIRELESS WORLD" "General Purpose Oscilloscope," full details available price 9d.

INDICATOR UNIT TYPE 62. Another handy unit containing the VCR97 Tube, 16 valves Type VR65, 2 of EB34, 2 of EA50, and shoals of condensers, resistors, etc. ONLY **75/-** (Carriage, etc., 12/6).

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RECEIVER A.E.W.1. A 5-valve superhet covering 550-1600 kc/s and 6-12 Mc/s in 4 switched wavebands. Operates from 6 v. D.C. source through built-in vibrator pack, and has large separate speaker in metal cabinet with 50ft. extension lead. Made for New Zealand Forces Welfare Dept.; these sets have 2.5 watts output and are NEW AND UNUSED. Valve line up: 6U7 RF Amp., 6K8 Mixer, 6U7 IF Amp., 6Q7 2nd detector, 1st Audio, 6V6 Output. The set is fitted with a large open slow-motion tuning dial, size 7in. × 3in., and both set and speaker are finished in olive green crackle. An ideal receiver for caravans, coaches, country areas, etc. ONLY **£9/19/6** (Carriage etc., 10/6).

RECEIVER 25.73. Part of the TR1196. Covers 4.3-6.7 Mc/s, and makes an ideal basis for an all-wave superhet receiver. Complete with six valves, 2 each EF36, and EF39, and 1 each EK32 and EBC33, and also modification data. ONLY **22/6** (Postage, etc., 2/6). **OSMOR ALL WAVE COIL PACK** recommended for this conversion, **40/6.**

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BATTERY SUPERSEDER. A 2 v. vibrator power unit designed for the Canadian Forces, which requires very little modification for use with anything that needs HT Batteries. For the cost of charging a 2 volt accumulator you have a source of constant H.T. Will save the price in a few months. Full modification details supplied. ONLY **60/-** (postage 1/6), or with Two 2 v. accumulators in metal case, ONLY **90/-** (carriage 5/-).

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CONDENSERS. 0.1 mfd. 2,500 v. tubular, **2/6**; 0.1 mfd. 3,000 v. block, **4/6**; 8 mfd. 450 v. **2/-**; 8 × 8 mfd. 450 v. **2/9**; or 6 for **15/-**; 8 × 16 mfd. 350 v., **4/-**; or 6 for **22/6**; 16 × 16 mfd. 450 v., **4/6**; or 6 for **28/-**; 32 mfd. 350 v., **2/9**; or 6 for **15/-**. Postage please under 20/-.

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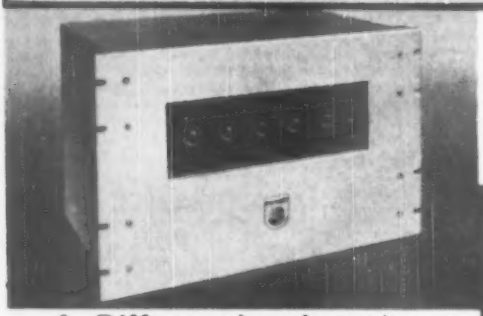

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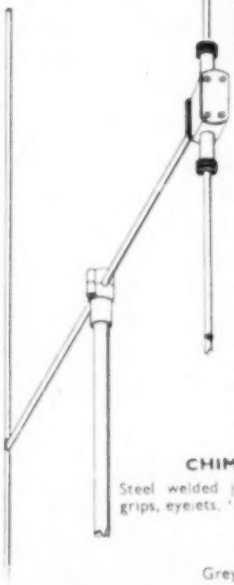

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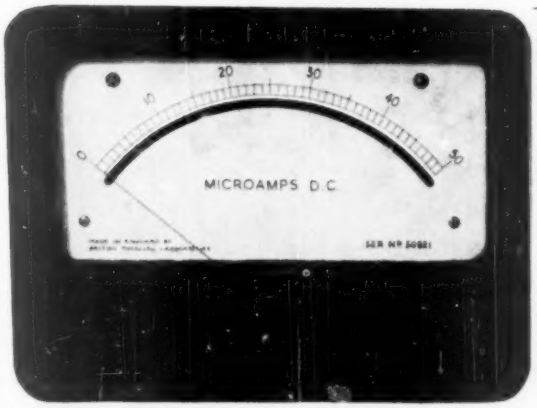

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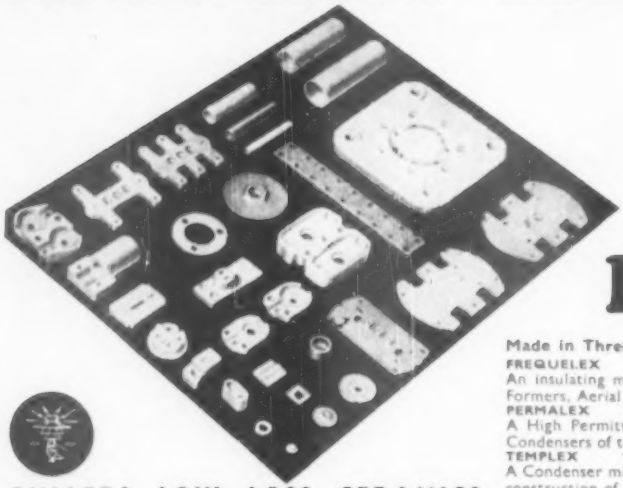

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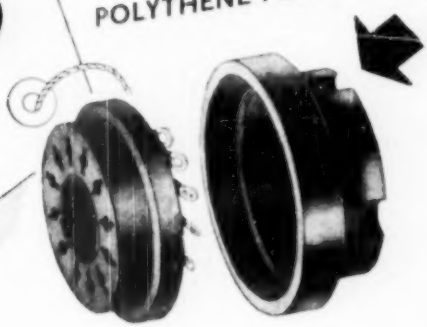

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The complete transmitter is housed in a tall console cabinet, superbly finished, and has a very attractive appearance. Side and rear panels are removable, and electrical interlocks are fitted as a safety feature. Stylish panel controls are conveniently grouped, and clearly identified. Five Meters are employed to read Aerial, Plate and Grid currents, and Filament voltages. A modulation and keying indicator of the vapour column type is mounted on the front panel. The Type MI-19468 Crystal Multiplier, which we supply with the transmitter, slides into an aperture which is normally concealed by a removable panel. When employing this unit, the oscillator stage in the transmitter functions as an intermediate P.A. stage, or frequency multiplier, and whilst employment is optional, transmission over the entire transmitter frequency range, using low frequency crystals, is a distinct operational advantage.

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Audio-Input Level for 100 per cent Modulation	20 v.
A.F. Response	± 5 db from 400 to 7,500 cycles.
A.F. Harmonic Distortion	5 per cent r.m.s.
Power Input:	
Telegraph, Low Power	1.25 kW.
Telegraph, High Power	1.46 kW.
Telephone, 100 per cent Modulation	1.82 kW.
Power Supply Requirements	115-230 v., 1 phase, 50-60 cycles.
Regulation (Maximum)	5 per cent.

DIMENSIONS. Height, 58in. Width, 17in. Depth, 24in.

WEIGHT. 500 lb.

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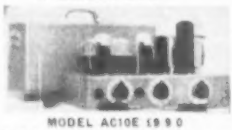

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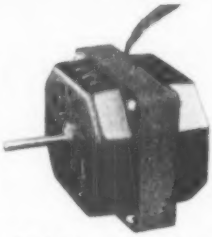

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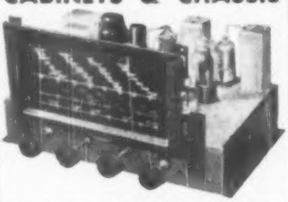
CABINETS & CHASSIS



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Telephone: HOLborn 6371.

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Television. Receivers Type 3585, complete with 45 mc/s. strip using 5 EF50's Diode (EA50) and Cathode follower, rotcher with a further 2 EA50's, 1 EF50, 4 S.'96's, 5 VR56, 3 VR55, 1 VR53, 1 VR54, also stacks of resistors and condensers, 2 5,000 and 2 1,000 relays, all brand new, in sealed boxes, at **£5 10/-** each.

Television. I.F. strips only, ex the above units, complete with 6 EF50's, 1 EA50, also brand new and unused, **62/6** each. Ditto, less valves, **37/6**. Limited number only.

Television. Unit type 208c, 2-stage 45 mc/s vision or sound, 2 EF50's, complete with full instructions, **14/6** each while they last.

Television. Brand new R1355 Receivers complete with valves, as used in the "Inexpensive Televisor." Suitable for London or Sutton Coldfield, **52/6** each.

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DOMESTIC RADIO KIT. In walnut bakelite cabinet 4 valve, T.R.F. Universal or A.C. for only **£4 15/6**, or in Ivory cabinet, **5/-** extra. Assembled **30/-** extra.

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FREE OFFER of phones with S.a. 15 superhet receiver, Short Wave, complete and working. Frequency range easily changed (I.F. 465). To clear, **17/6**. Instructions to make this All-Wave set. Money back guarantee, if not satisfied. Cash with Order please, and allow sufficient to cover postage. Stamps ONLY for lists.

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GOODMANS Audiom 60 £6/15, Axiom 12 £8/8.
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L. F. HANNEY, 77, Lower Bristol Road, Bath. Tel. Bath 3811. [6245

GARLAND RADIO, Chesham House, Deptford Broadway, S.E.8. Please see our displayed advertisement under name Garland Brothers on page 71. [0192

EHT Transformers, mains transformers, output transformers and chokes, open or bolted types, transformers designed to individual specification, singles or in quantity.
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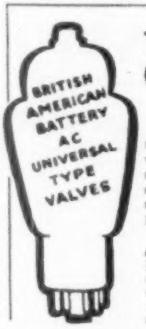

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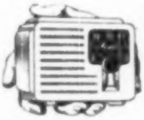

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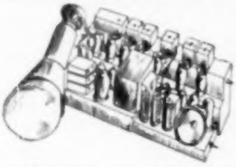

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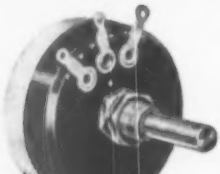

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Can be used for soldering aluminium, magnesium, duralumin and other metals which form refractory oxides.

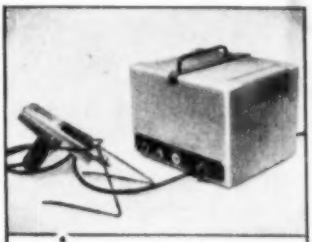
The soldering iron has a nickel silver bit driven by a magnetostriction transducer. The transducer is arranged to run at its natural resonant frequency by a feed-back system. A conventional low voltage winding heats the soldering bit.

THE problem of soldering metals which form refractory oxides has now been overcome. A new soldering iron, developed by Mullard, destroys oxide film by ultrasonic stimulation and provides a "clean" metallic surface.

This means perfect soldering of aluminium, magnesium, duralumin, etc., can now be achieved without scraping or brushing molten metals.

Standard soft solders can be used. And no flux is needed.

A small electronic amplifier supplies the ultrasonic power. There are no controls, apart from the mains switch, to operate. Unskilled workers can use the apparatus without discomfort, since the ultrasonic frequency used is inaudible to the human ear. Full information about the Mullard Ultrasonic Soldering Iron — the only commercial model in the world — is available on request.



The Mullard Ultrasonic Soldering Iron and Amplifier. The unit operates from A.C. mains and is robustly made to suit workshop conditions.

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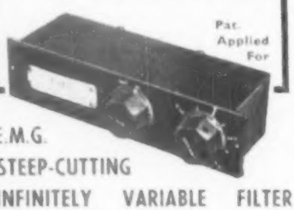

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INSTALLATION ENGINEER.—Required to undertake installation and servicing of very complex equipment; good personality, confidence in tracing obscure electronic faults absolutely essential; previous association with medical work an advantage (Ref. IE).

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EXPERIENCED and qualified radio and television engineer required, Kensington area, highest wages to experts only.—Tel. Frobisher 7464 appointment. [6173]

EXPERIENCED television and radio engineer of high standard required by well-established firm.—Apply, Barnes & Avis, Ltd., 140-1, Friar St., Reading. [6208]

ENGINEERS required for high frequency cable testing.—Apply, giving age, experience and salary required, to Ref. 425, Siemens Bros. & Co., Ltd., Woolwich, S.E.18. [6214]

FOREMAN required for R.F. gluing department; must be fully capable of designing jigs and controlling R.F. generators; excellent salary.—Apply Radiant Ltd., Garman Rd., N.17. [6211]

E. K. COLE, LTD. (Malmesbury Division) invite applications from electronic engineers for permanent posts in development laboratories engaged on long-term projects involving the following techniques:—

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PILOT RADIO Ltd., requires immediately fault finders, testers and mechanical inspectors for radio and television alignment, experienced in factory production; five-day week with good rates of pay.

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TELEVISION and radio engineers required for service department; able to drive service van; permanent position with good working conditions; staff discount.—Write or call Staff Controller, Rentals of Kingston. [6187]

JUNIOR test engineer for P.A. and electronic musical instruments; experience in latter field not necessary but should have good musical ear; most suitable opening for a technician just leaving the Services.—Write Box 7716. [6209]

WIREMEN required for electronics section of large electrical instrument manufacturers.—Apply, with details of experience, etc., to Personnel Manager, Elliott Bros. (London) Ltd., Century Rd., Lewisham, S.E.13. [6205]

RADIO and television engineer required immediately, fully qualified and able to drive; state salary required, with details of qualifications and experience; good prospects.—Apply E. Barden & Sons, 257, Bexley Rd., Erith. [6217]

ELECTRICAL inspector for mains and audio transformer test department; previous similar experience essential; N.W. London.—Write, with full details of age and salaries earned, to Personnel Manager, Box 7315.

ELECTRICAL engineers or physicists required with experience in the theory and practice of servo mechanisms and analogue computors for interesting new development work near London.—Apply, mentioning ref. DEP, to Box 4252. [5794]

SERVICE mechanic required for leading hearing aid firm, West End; must be fully qualified and experienced in miniature L.F. amplifiers; state age, experience and salary required.—Box M.1926, Haddons, Salisbury Sq., London, E.C.4. [6189]

TELEVISION RADIO service engineer, fully experienced, able to drive; permanent position with excellent opportunities; full particulars, references and salary required to W. J. Elliott Ltd., Howardsgate, Welwyn Garden City, Herts. [6081]

EXPERIENCED television aerial riggers required for Cricklewood and Maidstone; current driving licence and working knowledge of radio essential.—Write, stating age and wages required.—Antiference Installations, Ltd., Watford Way, N.W.7. [6203]

SERVO engineers for experimental work are required by a prominent aircraft concern; applicants, preferably under 35 years of age, must be educated technically to degree standard and have experience in the design of one or more of the following: hydraulic systems, servo amplifiers, small electrical mechanisms.—Apply, stating age, experience and salary required to Box 6954. [6246]

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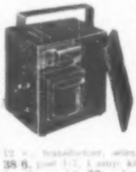

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SITUATIONS VACANT

ASSISTANT mechanical engineer required by large well-known firm to undertake mechanical design of interesting new electro-mechanical equipments, the work will be varied and the prospects good.—Apply, quoting Ref. GHR, to Box 1812. [6195]

FOREMAN for assembly of radio and electronic equipment in factory located South Wales, wide experience in Government contract work desirable, apply giving full details of experience to Personnel Department, Margam Radio, Ltd., Wexham Garden, Slough. [5965]

TEST engineers required for design and maintenance of apparatus for production testing of radar, communications and electronic equipments, salary according to qualifications and experience.—Full details to the Personnel Manager, E.M.I. Ltd., Hayes, Middx. [6001]

DESIGNER of audio and radio transformers required, experience of commercial design very necessary (must be able to produce full manufacturing and test specification), interesting position, N.W. London area. Write, stating experience, age and salaries earned, to Personnel Manager, Box 1814. [6197]

MECHANIC required for the construction and servicing of industrial electronic apparatus, maintenance of electro-mechanical transducers, etc. West London area. Forward details of education, experience and salary required to Box A.E.151, Central News, Ltd., 17 Moorgate, London, E.C.2. [6154]

RADIO engineers required, the General Electric Co., Ltd., are expanding their radio development laboratories at Coventry, and a number of vacancies for senior and other engineers exist at present and a further considerable number of vacancies will arise during the next few months in the new laboratory.

APPLICATIONS are invited from development engineers with experience of microwave radio or radar techniques who are capable of developing equipment and components to service specifications.

WRITE, quoting Ref. CHC/151, to Personnel Office, General Electric Co., Ltd., Radio & Devices Works, Spon St., Coventry. [5979]

A TELEVISION receiver manufacturing company in the North West requires a chief engineer, only experienced engineers interested in the design and progressive development of a range of high quality receivers for quantity production need apply, write giving full details mentioning ref. DOG to Box 6788. [6011]

A NUMBER of senior and junior engineers for radio, radar, electronic, television, etc., development, service engineers, draughtsmen, foremen, testers, technicians and experts required 50 television service engineers.—Write in confidence, Technical Employment Agency, 178 Clapham Rd., S.W.9. (Brixton 3441). [6048]

ELECTRONIC engineer required for development work in expanding industrial electronic team of well-known manufacturer in company, previous experience of servo mechanisms and industrial process control, together with degree or H.N.C. essential.—Apply, giving full details quoting Ref. GRR to Box 7815. [6196]

RADIO valve engineers, the M.O. Valve Co. have vacancies for qualified engineers in connection with the development, manufacture and application of radio valves, please apply by letter stating particulars and salary required to Personnel Department, The M.O. Valve Co., Osram Works, Brook Street, Manchester. [6198]

RADIO engineer or physicist with experience of design and construction of electronic equipment used in research and able to develop new equipment, salary up to £600 p.a. according to qualifications.—Apply in writing to Laboratory Superintendent, Physics Department, Imperial College of Science, South Kensington, S.W.7. [6126]

RADIO engineers, with qualifications over the full City and Guilds course on radio communications required by large radio manufacturer in eastern area of London in supervisory capacity, the experience gained in service of the Forces will be preferred. Kindly state full details including age and salary required to Box 1813. [6199]

PHYSICIST or electronic engineer required for the development of apparatus for physical measurements, preferably involving design, standard of experience with several years of practical experience, full particulars, age, qualifications, experience, salary required, etc., to Box A.E.152, Central News, Ltd., 17 Moorgate, London, E.C.2. [6200]

DRAUGHTSMEN (electrical) with experience of schematic or detail wiring diagrams, are invited to apply for progressive positions in the Drawing Office of the English Electric Co., Ltd., Liverpool, stating particulars of their career, ref. 141 to Central Personnel Services, English Electric Co., Ltd., 24-30, Gillingham Street, London, S.W.1. [6201]

ADMINISTRATIVE engineer with experience of technical correspondence and preparation of contracts required by department of Midlands firm engaged in electronic equipment, six months and R.F. [illegible] salary £400-£500 per annum according to experience.—Write, giving details of age and experience, mentioning reference BRS to Box 7811. [6136]

A VACANCY exists with a well-known electronic engineering firm near London for a technical writer, duties will be to originate technical sales literature of all kinds, to deal with enquiries and liaison, and to liaise with British engineers within the company, experience gained should, rather than the company's own products and equipment, be obtainable in a similar industry. Applicants should have a good general knowledge of telecommunications, be between 21 and 30 years of age and have an adequate knowledge of English.—Write, giving full details, mentioning Ref. BGH to Box 7820. [6125]

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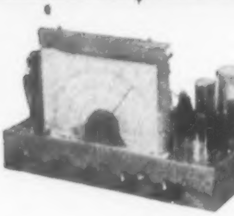

Luxury 8 valve Radiogram chassis with 7 watt triode push-pull output stage and wide range electronic tone control circuit. Designed to provide high fidelity reproduction from microgroove recordings as well as the standard 78 r.p.m. recordings. Circuit includes variable selectivity, cathode follower detector, audio frequency response 30-20,000 cycles within 1db. Price **£21/5/-**.

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ELECTROLYTICS. 8 mfd. 450 v. Small Met. Tubs. 1/11 ea.; 16 mfd. 350 v. Small Cans 2/3 ea., 18/6 doz.; 8-16 mfd. 450 v. Cans, 3/6 ea.; 50 mfd. 12 v., 8d.; 4 mfd. 200 v. Tubs. 5/- doz.

SMOOTHING CHOKES. 40 ma. 10 h. 360 ohms, 3/3; 60 ma. 15 h. 400 ohms, 4/3 ea., 42/- doz.; 80 ma. 12 h. 350 ohms 5/3 ea., 45/- doz.; 100 ma. 10 h. 100 ohms, 200 ma. 5 h. 100 ohms, 7/6 ea., 66/- doz.

OUTPUT TRANS. 6V6 to 2-3 ohms (Small), 1/11; Push-pull 10 w. 6V6, PX4, 6L6 to 3-5-8-15 ohms, 15/-. Williamson type exact to author's spec., 63/-.

MISC. ITEMS. Ex-Govt. Aladdin Coil Formers, slug tuned, 4/- doz. Clix Int. Oct. Valve Holders, 2/9 doz. Ex-Govt. Chokes 90 ma. 15 h. Trop., 3/9. 8in. M.E. Speakers 1,000 ohm Field, with 5,000 ohm Pentod. Trans., 14/11. T.V. Masks, 12in. Cream, 12/9.

TERMS. C.W.O. or C.O.D. over £1. Post extra under £2. Full list 3d. Special List for Trade 3d.

SITUATIONS VACANT

E. K. COLE, Ltd., have vacancies in their electronics division at Malmesbury, Wilts, for senior and intermediate draughtsmen in the Development Drawing Office, for work on radar, communications and electronic projects; previous experience in this field desirable but not essential.—Apply in writing to the Personnel Manager, Ekco Works, Malmesbury, Wilts. [6086

A NORTH Midlands firm requires electronic engineers experienced in maintenance and design of electronic equipment, to work on the measurement of vibrations of engines, etc.; some mechanical knowledge, strength of materials, etc., an advantage; Higher National Certificate minimum qualification; salary £400 to £500 p.a. according to experience.—Box 6787. [6021

ELECTRICAL component manufacturers, situated in W. London, require intelligent person to take charge of special test section; applicants should possess Inter-B.Sc., or equivalent, have previous experience of test and measuring equipment and be capable of maintaining accurate records.—Write, stating age, experience and salary required, to Box 6796. [illegible]

DEVELOPMENT engineer (electronics) required by old-established company, to be responsible for the design and development of specialized radar and electronic instruments; applicant should have good circuitry experience in time-base, pulse and C.R.T. techniques; preferably conversant with Service design requirements; state age, experience and salary expected.—Box 6965. [6113

RADAR, radio and/or electronics senior development engineer wanted for work on important defence project in special English Electric Co. laboratory; salary £600-£900 p.a. according to experience; write giving details of qualifications and previous experience mentioning reference 456A to—Central Personnel Services, English Electric Co., Ltd., 24/30, Gillingham St., London, S.W.1. [6105

RADAR technicians are required by a well-known firm of radio manufacturers for a factory in South Lancashire; experience in the servicing and/or installation of radar equipment is essential; persons who have had experience in this type of work in the Services would be particularly suitable; good salaries, according to experience; write, giving full details, mentioning Reference HAR, to Box 6959. [6089

VACANCIES exist at Chelmsford for a rate-fixer with a knowledge of time study for light engineering machine shop, and planning and time study engineers for sheet metal and framework sections.—Write, giving details of age, previous experience and salary required, mentioning reference 445A, to Central Personnel Services, English Electric Co., Ltd., 24-30, Gillingham St., London, S.W.1. [6211

AN experienced valve engineer is required for employment at Chelmsford; applicants should be 25-35 years of age, qualified engineers and preference will be given to applicants with previous design or production experience of small transmitting valves; write giving full details of previous experience mentioning ref. 497B to—Central Personnel Services, English Electric Co., Ltd., 24-30, Gillingham St., London, S.W.1. [6099

A WELL-KNOWN radio manufacturing company in the South require senior experienced radar development engineers to lead teams working on nationally important radar projects; attractive salaries will be offered to suitable applicants, houses will be available for key men, the company has an excellent pension scheme.—Apply giving full details of qualifications and previous experience mentioning ref. DGD to Box [illegible]. [6122

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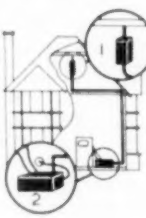

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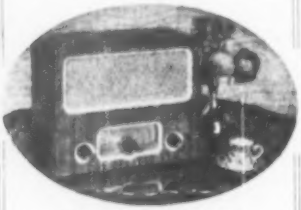

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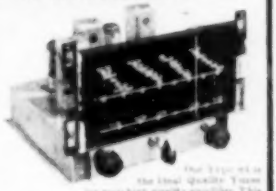

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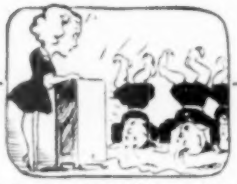

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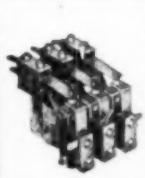

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Not only are they suitable for working up to the voltage stated but they will operate up to 71°C at 80% of the rated voltage

"LECTROPACK" DRY ELECTROLYTIC CONDENSERS

THE TELEGRAPH CONDENSER CO. LTD. RADIO DIVISION · LONDON · W.3 · Tel. Acorn 0061 (9 lines)

"I HAVE TESTED EVERY MAKE OF U.S.A. AND EUROPEAN CORED SOLDER, BUT

I prefer ERSIN MULTICORE

–it's always so reliable"

SAYS MORTON LEE, U.S.A. CUSTOM TELEVISION AND RADIO SPECIALIST

Mr. Morton Lee, who builds specialised television, radio and gramophone installations for wealthy homes and institutions, uses only Ersin Multicore Solder in the equipments he makes. A typical installation, built into a room, includes a 12 channel 19" tube television receiver, high fidelity FM and AM radio receivers, a 3-speed high fidelity record reproducer, disc and tape recorders, and a cine film synchronised reproducer.

For each equipment he must be sure that every one of his thousands of soldered joints is a perfect electrical connection, and will remain sound and free from corrosion during the life of the equipment. Mr. Lee says : " In my laboratory I try all cored solders and over 10 years I have found that Ersin Multicore is the only solder which is of the same consistent high quality—I use only this for my installations."

7 lb. Reel (prices on request)

SIZE 1 CARTON—5 - RETAIL

USED BY LEADING U.S.A. MANUFACTURERS

Many leading U.S.A. Television manufacturers — some with an output of more than 1,500 sets per day—prefer to pay the import duty and freight charges on British-made Ersin Multicore, rather than use American-made solder. They find that Ersin Multicore, the only solder containing 3 cores of extra-active non-corrosive Ersin Flux, gives them faster production, greater soldering reliability, and lower cost per soldered joint. It always pays to use only Ersin Multicore Solder—The Finest Cored Solder in the World—for economy with quality.

Catalogue Ref. No.	Alloy Tin/Lead	S.W.G.	Approx. Length per carton
C16014	60/40	14	18 feet
C16018	60/40	18	47 feet
C14013	40/60	13	16 feet
C14016	40/60	16	34 feet

MULTICORE SOLDERS LTD.